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JUNE 30, 1964

Eleventh SEMIANNUAL REPORT TO CONGRESS

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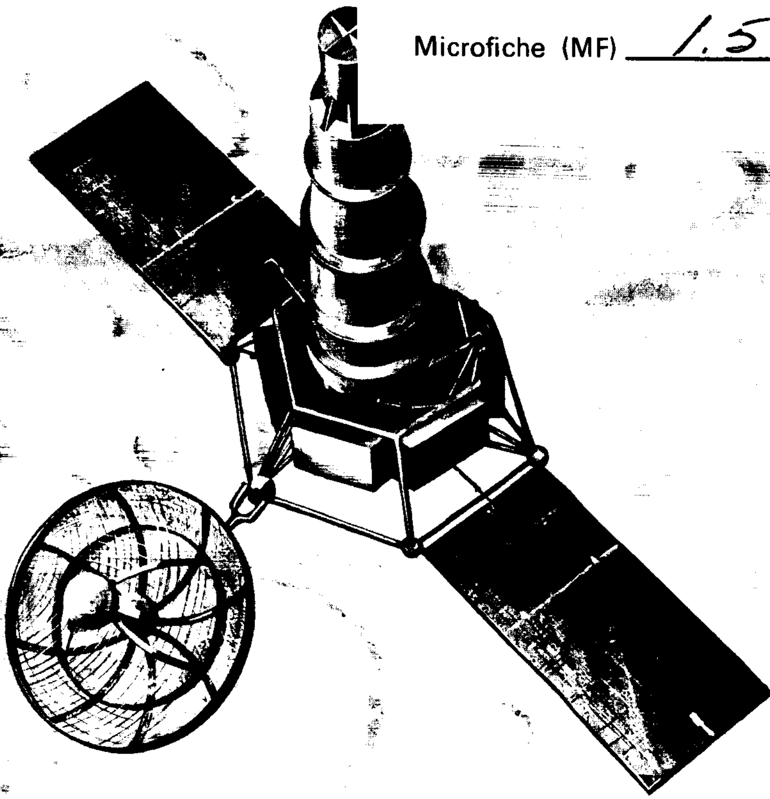

RANGER VII

Eleventh SEMIANNUAL REPORT TO CONGRESS

JANUARY 1 - JUNE 30, 1964

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D. C. 20546

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JANUARY 25, 1965

To the Congress of the United States:

Pursuant to the provisions of the National Aeronautics and Space Act of 1958, as amended, I transmit herewith a report of the projects and progress of the National Aeronautics and Space Administration for the period of January 1, 1964, through June 30, 1964.

This report covers in enlightening detail 6 months of accomplishment. Problems of technological complexity as well as those of managerial difficulty have been met with a sense of awareness of the contributions the national space program is making toward human welfare and world peace.

THE WHITE HOUSE.

NOVEMBER 13, 1964.

The PRESIDENT,
The White House.

DEAR MR. PRESIDENT: This 11th Semiannual Report of the National Aeronautics and Space Administration covering the period January 1 through June 30, 1964, is submitted for transmittal to Congress in accordance with Section 206(a) of the National Aeronautics and Space Act of 1958.

We have prepared the report in two parts. The first section is a concise summary of NASA programs and progress, and the second is a detailed discussion of the Agency's activities.

Among the highlights of the period were these accomplishments:

Echo II launched January 25.—This passive communications satellite supported the first cooperative communications experiments with the U.S.S.R.

Fifth successful Saturn I test flight January 29.—First flight using live second (S-IV) stage; first Saturn I orbital mission; orbit of largest object by United States to that time (37,700 pounds); major step forward in the Saturn program.

First unmanned Gemini flight April 8.—First flight of Gemini spacecraft; a significant achievement of the manned space flight project that follows Project Mercury; second largest object launched into earth orbit by the United States at that time; verified effectiveness of the Titan II launch vehicle.

Sixth successful Saturn I test flight May 28.—First test to use an unmanned Apollo (boilerplate) spacecraft; test underscored soundness of the Saturn design.

In addition, NASA launched an improved Relay II satellite on January 21, Ariel II, a United States-United Kingdom geophysical satellite on March 27, and shortly after the end of the period (July 28), the highly successful Ranger VII, which, for the first time, relayed thousands of pictures of the visible face of the moon.

These achievements, together with a vast number of other scientific and technological advances, signify continued progress in our space program, provide a firm basis for the future, and point up the fact we are moving with deliberate speed toward the Nation's goals in space.

Respectfully yours,

JAMES E. WEBB, *Administrator.*

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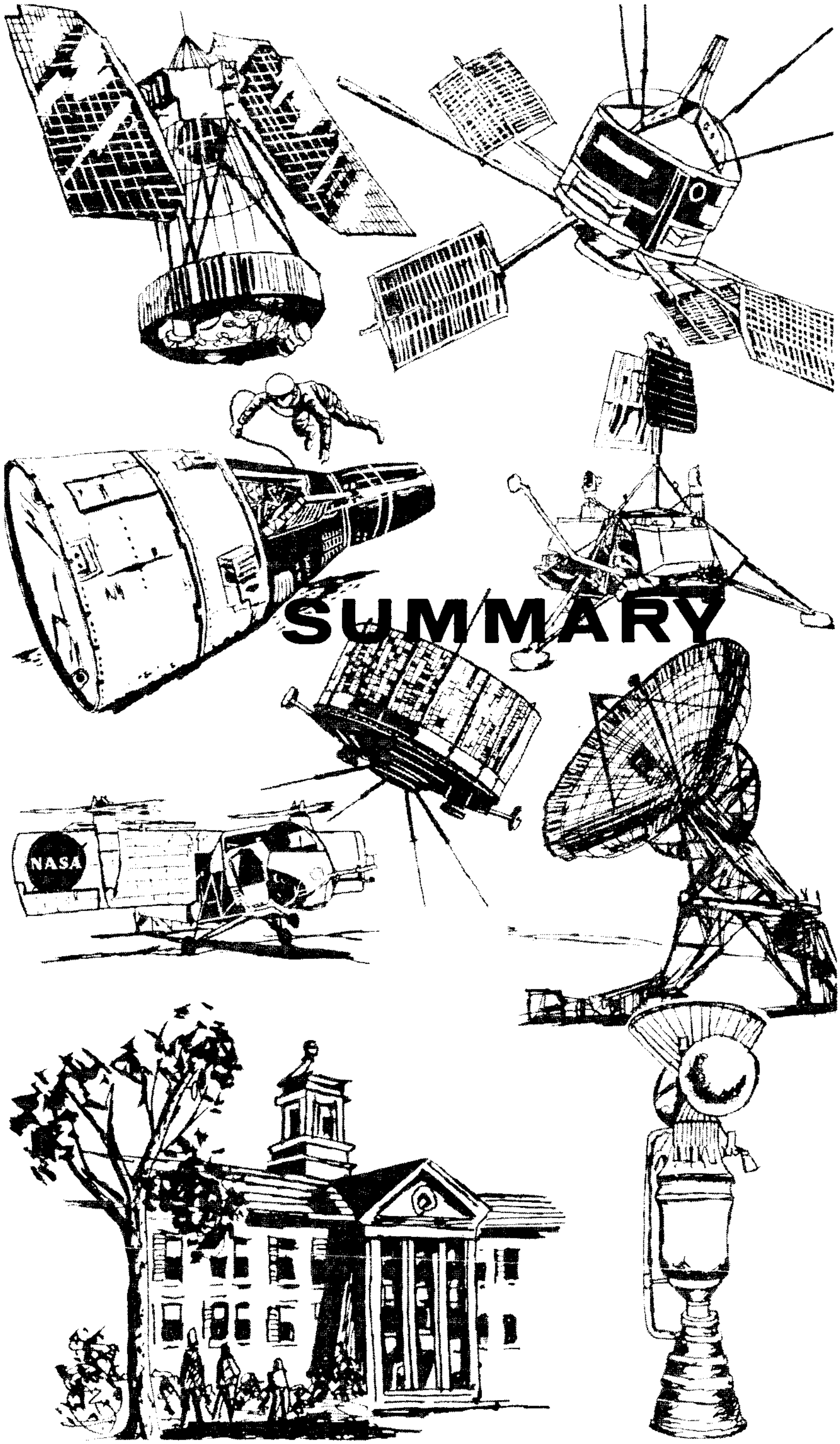

THE PERIOD IN REVIEW

During this reporting period, the National Aeronautics and Space Administration made advances in the design, development, and production of the equipment, in the acquisition of the scientific data, and in the development of the technology needed to achieve the national goal of preeminence in space. These achievements are summarized in the pages of this section which follow.

Manned Space Flight Network

Four successful major launches were conducted by the manned space flight program during the period; these brought the total of successful major manned and unmanned launches in this program to 16.

The Gemini program moved into the flight phase when, on April 8, the Gemini Spacecraft/Titan II Gemini launch vehicle (Mission GT–1) successfully passed the first flight test. Gemini spacecraft No. 2, meanwhile was being system tested and readied for delivery to the John F. Kennedy Space Center. Spacecraft No. 3, to be used for the first manned Gemini mission, was essentially completed. Spacecraft Nos. 4 through 9 were being fabricated, and components for subsequent ones were being made. Completed spacecraft and specific subsystems and components were being tested.

Development and manufacture of the Gemini launch vehicle continued, with special procedures being instituted to carry out the "man-rating" program. Of the 15 launch vehicles being procured through the Air Force for NASA, one was used in the April 8 flight, the second was erected at Launch Complex 19 (John F. Kennedy Space Center), the third was erected at the contractor's plant for systems testing, the fourth was being assembled, tanks for number five were delivered to the prime contractor, and components for the remaining 10 were in various stages of manufacture.

On the main engine of the Agena target vehicle Preliminary Flight Rating Tests were nearly completed and well along on the secondary propulsion. Also, modification of the system checkout equipment was nearing completion.

The Gemini missions were being planned in detail and documentation for the second mission was completed. The Mission Control Center and the Tracking Network were being readied to support GT–2; and the Manned Space Flight Control Center was planned for acceptance early in 1965.

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For the first manned Gemini flight, Maj. Virgil I. "Gus" Grissom was chosen as the command pilot and Lt. Comdr. John W. Young, the copilot. The backup crew is Lt. Comdr. Walter M. Schirra, Jr., command pilot, and Maj. Thomas P. Stafford, copilot.

Gemini space medicine efforts included work on crew equipment, pressure suits and life support systems, biomedical experimental studies, and medical flight operations. The training suit of the type to be used aboard the spacecraft was delivered to the Manned Spacecraft Center for evaluation and flight qualification; and a contract was awarded for life support systems of the type to be used by astronauts who will leave the spacecraft while it is in orbit.

Forty-one experiments were approved for Gemini—17 are to be technological; 12, scientific; 9, medical; and 3, special engineering experiments by the Manned Spacecraft Center.

In the Apollo program, plans were made to recruit scientist-astronauts, certain astronaut training was intensified, and scientific experiments were being planned. Of major importance were the fifth and sixth successful flights of the two-stage Saturn I.

The successful Saturn I (SA–5) flight of January 29 was the first to use both live stages (S–I and S–IV), first flight in the Saturn I program using liquid oxygen/liquid hydrogen as a propellant, first use of the uprated H–1 engines (from 165,000 to 188,000 pounds), first flight test of the instrument unit, and the first Saturn I orbital mission. The successful sixth flight of Saturn I (SA–6, May 28) was a more sophisticated version and the first test to use an unmanned boilerplate Apollo spacecraft (command and service modules). By the end of June, plans were well along for the seventh flight (SA–7).

Seven boilerplate test models and seven airframe vehicles of the spacecraft (command and service modules) were being fabricated and assembled. The test models for the Saturn I (SA–7) flight and the second Little Joe II abort test were undergoing development engineering inspections. Also, an Apollo boilerplate spacecraft was being prepared for integrated systems testing.

A first test model of the Lunar Excursion Module (LEM) vehicle was completed. (This is a full-scale replica made of wood and plastic.) The metal mockup was approximately 40 percent fabricated. In addition, fabrication of two of the nine ground test vehicles was underway.

Four guidance and navigation systems for the command module and the LEM had been fabricated by the end of the period; the first three were tested at the subsystem level. The fourth, following other tests, was delivered to the spacecraft contractor for use in spacecraft/ground support equipment integration.

With the Apollo spacecraft engines, phase I development of the service module engine was completed; two contractors were engaged in parallel effort to develop the engine for lunar landing of the LEM descent stage; the engine for LEM ascent was being developed; and subsystems were being designed for the reaction control systems of both the service and the command modules.

For the launch vehicle itself, the remaining H–1 engines for Saturn I first stages were completed and delivered, and the last two S–I stages were being manufactured. Also, the last three S–IV (second) stages were being fabricated.

Delivery of the Saturn IB H–1 engines (uprated from 188,000 to 200,000 pounds of thrust) began, and qualification testing at the higher thrust level was about 80 percent completed. The S–IVB (second) structural test stage was completed, the battleship test stage was undergoing cold flow tests, and fabrication of the first four flight stages was underway. Also, the instrument units were being fabricated and assembled for various tests.

Saturn V design and development was on schedule. Two S–IC (first) stages, the all-systems and structural test stage, and the first two flight stages were being assembled. A full scale S–IC mockup was assembled to establish wiring runs and tubing layouts, and to check out interface points. The S–II (second) stage battleship test structure was completed; and the structural, all-systems, dynamic, and facility checkout test stages were being fabricated and checked. The S–IVB (third) stage—similar to the second stage of the Saturn IB—was being designed and developed. Also, progress was made on both the F–1 and the J–2 engines.

Apollo general mission planning was well along and specific missions were beginning to be formulated. The Saturn I phase should give the Nation a firm technical base upon which to develop the more powerful vehicles. The Saturn IB program would go from launch vehicle and spacecraft heat shield development to long-duration earth orbital missions, including certain missions to develop lunar flight rendezvous and docking techniques. The Saturn V program extends from launch vehicle and spacecraft qualification flights to the lunar missions.

To provide manned space flight support, new facilities were being constructed: engineering and administration buildings, design and manufacturing complexes, development and aceeptance testing structures, launch complexes, and vertical assembly buildings. Also, steps were taken to provide or otherwise assure adequate propellant support.

Looking beyond Gemini and Apollo, NASA expanded the scope of studies for advanced manned missions in three basic areas—earth orbital, lunar, and planetary. Coupled with these three areas is a fourth one—launch vehicle systems (improvement of those now being developed and development of more powerful ones).

Scientific Investigations in Space

Craft orbited during this period and others launched earlier helped investigators obtain a clearer understanding of the space about the earth. Echo II, the passive communications satellite launched in January, provided geophysicists with air density data, and Ariel II, the second United States-United Kingdom geophysical satellite, launched in March, collected and transmitted data on radio frequency radiation, ozone in the atmosphere, and micrometeoroids.

Explorer XVII, launched April 1963, and still transmitting data, revealed daily variations in atmospheric density and information on physical and chemical processes in the upper atmosphere. Explorer XVIII (orbited November 26, 1963) supplied the most accurate measurements yet available of the strength and direction of the interplanetary magnetic field. And the Canadian geophysical satellite Alouette (launched by NASA September 28, 1962), returned data on the upper atmosphere and its dependence on solar radiation.

In the Ranger program, Ranger VI was launched on January 30 and landed on the moon on February 2, in the target area. However, its TV cameras failed to transmit during the 17 minutes before impact, presumably because of a premature turn-on during launch, and no pictures of the moon's surface were obtained. Ranger VII was modified to minimize the likelihood of such failure and underwent extensive testing during this period. After the close of the period (July 31), Ranger VII was launched and successfully accomplished its mission, transmitting thousands of excellent pictures of the lunar surface.

In other developments in NASA's lunar and planetary programs, two Mariner spacecraft were being readied to fly by Mars, and a contract was signed for the design of this country's first satellite of the moon. Surveyor (a far more sophisticated spacecraft than Mariner or Ranger) was being developed to make soft lunar landings, conduct experiments on the moon, and provide engineering and mapping data in support of future manned landings.

Bioscientists, acting on the recommendations of the Agency's Space Science Steering Committee, selected experiments for the first three payloads to be carried aboard recoverable biosatellites planned for initial flights in about 2 years. Experiments for these orbiting biological laboratories were chosen from 175 proposed by scientists throughout the United States. They will include general biology and radiation experiments, plant experiments, tissue cultures, small mammals, and a pigtailed monkey. There will be six flights in this series.

Further, significant advances were made in understanding the biological effects of weightlessness, cosmic radiation, gravitational forces, and other outer space stresses on various life forms—knowledge vital to man's exploration of the planets and interplanetary space.

In manned space science, NASA planned investigations designed to make maximum use of an astronaut's ability to perform efficiently in space. Inflight scientific experiments for the two-man Gemini missions were under preparation, and flight qualification testing of equipment for these experiments began in June. Detailed planning of investigations to be carried on by explorers of the moon also was underway.

Medium Launch Vehicles

NASA used Scout, Delta, Agena, and Atlas-Centaur medium launch vehicles to orbit spacecraft in its space science and applications programs during this period. A Scout successfully launched the second Ariel United States-United Kingdom geophysical satellite on March 27; a Delta boosted the Relay II communications satellite into orbit on January 21. The Echo II passive communications satellite was orbited in January by a Thor-Agena, and an Atlas-Agena launch vehicle launched Ranger VI on its journey to the moon in January.

Atlas-Agena and Thor-Agena were being prepared to launch a lunar photographic mission, an Orbiting Geophysical Observatory, a weather satellite, and two Martian fly-by missions in the latter part of 1964.

The third development flight of Atlas-Centaur took place on June 30. The first U.S. launch vehicle to use liquid hydrogen as a fuel, Atlas-Centaur will launch Surveyor spacecraft towards the moon, advanced spacecraft to Mars, and other satellites and space missions.

Satellite Applications

Relay II and the second Echo joined Telstar II, Syncom II, Relay I, and Echo I in space in January of this year to supply more data for scientists and engineers experimenting with communications satellites.

U.S. TV viewers saw the winter Olympics at Innsbruck, Austria, via communications satellites, and an estimated 165 million Europeans watched the world's heavyweight boxing match telecast from this country in the spring. In April, Telstar II linked Japan and Europe via communications satellite for the first time, and supplied radiation data which gave scientists a more accurate picture of the Van Allen belt.

Relay I became the first communications satellite to exceed its designed lifetime of one year, and Syncom II supplied thousands of hours of data. At the request of the Department of Defense, Syncom II was commanded to drift westward where it will be in a supporting location for Syncom III, which will be on station near the International Date Line in its planned orbit. (Syncom III spacecraft was launched from Cape Kennedy on August 19.)

In its navigation satellites program, NASA joined the Departments of Defense, Interior, Commerce, Treasury, and the Federal Aviation Agency in setting up an ad hoc committee to consider a system of spacecraft able to meet future air-sea navigation and traffic control needs.

Satellites and sounding rockets continued to offer unique advantages for research and operational meteorologists all over the world. And during this period, the first experimental Automatic Picture Transmission (APT) subsystem aboard TIROS VIII (launched Dec. 1963) supplied U.S. weather forecasters in remote areas with photographs of local cloud cover a few minutes after the photographs were taken.

The report period also saw plans completed for the Agency's Advanced Technological Satellites Program and an Advanced Technological Satellite Flight Project established under the management of Goddard Space Flight Center. Each Advanced Technological Satellite, using technology developed under Advanced Syncom, will be adaptable to various types of payloads and be designed for a 3-year lifetime. Experiments to be orbited on the spacecraft will include ones in communications, meteorology, and orbital environment. The first flight is planned for 1966.

In May, TIROS VII (orbited June 1963) established a new record of performance in this highly successful satellite series when it exceeded the 66,674 pictures—59,830 of them meteorologically useful—taken by the sixth TIROS. The next in the series, TIROS I (Eye), was being prepared for launch. Built like a cartwheel, the spacecraft will have cameras looking out through its sides and will be able to take earth-oriented pictures throughout the sunlit portion of each orbit.

During the first 6 months of 1964, the prototype Nimbus spacecraft, an advanced meteorological observatory in space, passed its qualifying tests. The first flight spacecraft—Nimbus A—was being prepared for its scheduled launching during the third quarter of 1964. (Nimbus A was successfully orbited as Nimbus I on August 28.)

Advanced Research and Technology

Efforts in this area covered the broad fields of space-power technology, space vehicles, spacecraft electronics and control, aeronautics, biotechnology and human research, advanced chemical propulsion systems, and basic research.

In space power technology, experimental radiation-resistant solar cells were evaluated and a highly efficient thermionic generator was demonstrated. Research continued on lightweight, high-precision mirrors for focusing solar energy, the laboratory experimentation phase of the Sunflower research and development effort was completed, and work continued on identifying and resolving major technological problems associated with a closed cycle argon-Brayton power generation system. Work progressed on an internal combustion engine generator set capable of operating on hydrogen and oxygen, on experimental d.c.-to-d.c. converters, and on solid state current limiters. Also during the period, NASA cooperated with the Department of Defense and the Atomic Energy Commission in a review of the entire national space power systems research and development program to determine its adequacy, timeliness, and balance in relation to future needs. This study was initiated under the auspices of the Aeronautics and Astronautics Coordination Board.

Space vehicle systems research was extended with additional manned flight tests of the advanced lifting body, successful testing of a balloon for spacecraft or booster recovery, and continued work on high energy radiation and shielding. Construction of the Langley Space Radiation Effects Laboratory was on schedule, additional data were collected for use in attempts to measure the mass of meteoroids entering the atmosphere, and three larger Saturn-launched satellites and another Explorer XVI type spacecraft for meteoroid penetration research were under development. High-vacuum technology investigations involved experiments with cesium metal to treat a glass vacuum system, studies of cold welding of structural metals, and research on cryopanels. Research on passive temperature control systems for spacecraft indicated that a zinc oxide pigment paint in a silicone resin medium may be useful.

Spacecraft electronics and control research included a flight test to make measurements relating to the spacecraft reentry communications blackout, studies of the data acquisition capability of ground antennas and of an array of deep-space receiving antennas, and investigations of ways of improving microelectronic devices. Significant progress was made in developing attitude control components to provide long periods of reliable operation in space; in advancing the cryogenic gyroscope research project; and in the development of a field calibration standard, force measuring instruments, a working module of an image converter, and a vacuum gage which can respond to pressure changes over a wide range in less than 200 microseconds.

Data processing research sought to increase reliability, efficiency, utility, and flexibility of the computer system. New test techniques were studied, a new type of computer memory was under investigation, and work progressed on systems using a liquid or gas as the working substance. Operating speeds of computers which use both digital and analog circuits were increased and their power to solve problems was enhanced.

In aeronautics research, flight tests were initiated in a general aviation aircraft handling quality program. Aerodynamic research included studies on boundary layer control, heating at supersonic speeds, and on fuselage shapes for hypersonic cruise aircraft. The aircraft structural research program continued investigations of the heating of stainless steel and titanium alloys, of the effect of thermal stresses and buckling on the flutter of skin panels in a supersonic airstream, and of refractory materials such as columbium and molybdenum for use in hypersonic aircraft. As part of a long-range propulsion research program, a project was initiated to design, develop, and build an experimental hypersonic, hydrogen-fueled ramjet engine.

In supersonic transport studies, aerodynamic refinements developed were applied to the wing design of the SCAT–15 (Supersonic Commercial Air Transport) concept to produce an improved configuration (SCAT–15F) with better flight characteristics and a 15-percent increase in range. Studies of large volume hydrogen-fueled hypersonic transports in the Mach 4 to 8 range indicated the likelihood of excellent performance and range.

Two of the X–15 research craft continued flight tests during the greater part of the period to collect data on optical degradation, heat transfer, boundary layer noise, and skin friction. The third craft, the X–15 No. 2, was returned to NASA following rebuilding, changes in the propellant tanks and windshield configuration, and improvements in the landing gear, research instruments, and speed capability.

Vertical and Short Takeoff and Landing (V/STOL) aircraft studies indicated the feasibility of using a fan-in-wing concept. Tests were completed on the tilt wing flying "test bed" and data will be used in the development of more advanced tilt wing V/STOL aircraft. This craft also served as a V/STOL flight training aid.

In NASA's diversified biotechnology and human research program, life support systems, bioinstrumentation, displays and controls, and protective techniques and devices were investigated. Studies of the vestibular system, of the biological effects of magnetic fields and radiation in space, and of man-system integration also continued.

A 30-day test of an integrated 5-man life support system was completed and regenerative systems were under development. Bioinstrumentation efforts were concentrated on the development of a closed loop man-machine control system and the associated sensor subsystem. Surgically implantable bioinstruments—an automatic perfusion pressure regulator, an implantable oximeter, and an interarterial manometer—were also developed. To simplify man's task in controlling spacecraft equipment, a contact analog display device was being fabricated and a voice input control system being developed. Protective techniques and devices being investigated included a hard suit, a passive suit, and an airbag restraint system.

Human research projects studied the vestibular system, the biological effects of magnetic fields, and the effects of the types of radiation encountered in space. Research on the relative biological effects on bacteria of protons in the 22–730 Mev range was completed. Man-system integration studies of crew confinement showed no apparent stress or dropoff in performance, but irritability, hostility, a drop in positive mood, and visual changes did occur. And vibration was found to affect the ability of a pilot to control a high-thrust booster vehicle.

In chemical propulsion systems research, a program was established to manufacture and test 260-inch diameter solid fuel motors. Liquid propulsion research ranged from work on systems developing only a few pounds thrust to efforts on the M–1 liquid oxygen-liquid hydrogen engine of the 1.5-million-pound-thrust class. Investigations of liquid fluorine-liquid hydrogen as a propellent combination advanced, and efforts were initiated to design a universal 100-pound-thrust auxiliary engine for attitude control and maneuvering in space. Studies were made of increased chamber pressure and associated problems of stress levels, materials, fluid flow rates, bearings, seals, and pumps. Research showed the feasibility of augmenting the thrust of rocket engines by deriving air from the atmosphere. Further work on space storage of high energy liquid hydrogen indicated that gelling could reduce evaporation, sloshing, and zero gravity problems. Related research on oxygen difluoride/diborane, an inherently space storable propellent combination, progressed significantly, and several studies were begun to acquire better information about the ablation process in thrust chambers and nozzles.

Basic research included work on heat transfer conditions likely to be encountered on entry into the Martian and Venusian atmospheres. A prototype hypervelocity wind tunnel was developed for reentry research. In applied mathematics, an improved procedure for numerical integration of differential equations by power series expansion was developed. Materials research on stainless steel and titanium alloys indicated that the problem of fatigue will be no greater in the supersonic transport than it has been in the subsonic transport. And in electrophysics, a significant advance was achieved in the use of X-ray spectroscopy for investigating the atomic structure of matter in the 15–40 angstrom wavelength region.

Nuclear Propulsion and Power Generation

In the joint NASA–AEC SNAP–8 project, experimental liquid metal test loops were being constructed and experimental test hardware items fabricated. Testing was started or underway on the alternator, the turbine-alternator assembly, the experimental reactor, and a number of corrosion loops for testing the reactor piping system.

With nuclear electric power research, testing of a multitube condenser was completed, a centrifugal pump was run for 350 hours, the stability of water-lubricated journal bearings was investigated, and out-of-pile life tests of thermionic converters were underway.

In the electric propulsion program—involving electrostatic, electrothermal, and electromagnetic engines—a small electrostatic (cesium contact ion) engine was completed and was being evaluated in the laboratory. Work on larger engines (3 kw to 30 kw range) for prime propulsion was being directed toward determining performance capability, durability, and scaling effects. A 3-kw cesium electron bombardment engine was fabricated and tested; and a 3-kw linear-strip cesium contact ion engine was being fabricated.

A resistojet (electrothermal) 3-kw thrustor design was run at a specific impulse of 800 seconds for 50 hours with no measurable deterioration. A concentric tube heat exchanger was being investigated; and plans were made to complete a simulator evaluation of the resistojet for stationkeeping and attitude control. In addition, radiation-cooled arc jets were subjected to runs of better than 30 days, showing that electrode erosion was not severe and no longer a limiting factor.

With electromagnetic engine research, the performance of pulsed plasma accelerators was substantially improved. Also, energy storing techniques were improved by replacing capacitors with distributed parameter pulse lines.

The KIWI project was marked by two major reactor experiments. In February, features redesigned to eliminate the core vibration problem were checked through KIWI–B4D cold flow reactor tests with satisfactory results. In April–May, practically all objectives were met or exceeded in a second experiment.

After a NERVA reactor configuration was subjected to cold flow tests, preliminary analyses of the test data indicated that the cryogenic runs produced no abnormal pressures, pressure drops, or vibrations. Major emphasis was also placed on such NERVA non-nuclear components as the turbopump, the liquid-hydrogen jet-cooled engine nozzle, and certain essential controls and valves.

NASA also continued the essential research and technology efforts supporting KIWI and NERVA: reactor research, nonreactor component development, vehicle technology development, and flight safety.

Tracking and Data Acquisition

NASA tracking networks provided support for the first Gemini unmanned launch, the Saturn SA–5 launch, the Saturn SA–6 launch, and the Ranger VI launch. Additionally, the Satellite Network provided support for seventeen NASA and six DOD satellites.

The operational capability of the Satellite Network was improved by the installation and checkout of medium-gain antenna installations (40-foot parabolic dishes) at Quito, Ecuador, and Johannesburg, South Africa. Also, a Satellite Telemetry Automatic Reduction System (STARS) was installed to perform a number of data processing functions, thus expanding the capability to handle increasing amounts of data.

For the Deep Space Network, construction of the S-band 85-foot antenna station near Madrid, Spain, was started and was on schedule for one at Canberra, Australia. Work went forward on the S-band prototype 210-foot parabolic antenna station at Goldstone, Calif.

The control room at Woomera, Australia, was altered to add space for supporting equipment for Mariner. The Pioneer station at Goldstone was modified to accept S-band equipment. And a backup circuit was established (South Africa to Australia, to Hawaii, to the United States).

For greater safety and more reliable acquisition of Gemini flight data, the Manned Space Flight Network was improved in the following ways: Radar tracking systems were installed at some stations; telemetry systems were installed and combined with the command systems to provide dual capabilities; and both HF and UHF voice communications were installed. This network is to be further augmented with antennas and with command, telemetry, and communication systems being planned during the period.

International Programs

NASA's international programs achievements included the successful launching of Ariel II (a cooperative United States/United Kingdom scientific satellite); the decision to launch a French satellite on a

NASA vehicle; and successful sounding rocket launchings from the Thumba range in South India, the Norwegian range at Andoya, and the Sonmiana Beach range in Pakistan.

A Nike-Cajun rocket, fired on March 25, was a United States-Italian effort; the launch was made from the San Marco platform off the East Coast of Africa. Through the joint United States-Norwegian-Danish program, ionospheric payloads were launched from the Norwegian range north of the Arctic Circle. Two Judi-Dart sounding rockets and a Nike-Apache/sodium vapor payload were launched from the Paskistan range. Under the U.S.-U.S.S.R. Bilateral Space Agreement of 1962, the first specific performance occurred in the form of a series of joint long-distance telecommunications tests, using Echo II. The Soviet Academy of Sciences participated with NASA in these tests. Cooperative projects also continued with Sweden and with the United Kingdom.

Through various international agreements, NASA received operations support from Spain (tracking and data acquisition station being constructed near Madrid); Australia (location and operation of Syncom III telemetry and command equipment near Adelaide); Canada (agreement for a command and data acquisition station); Nigeria (continued operation of the communications and data acquisition station), the Philippines, and Zanzibar.

NASA also received cooperation through international organizations, including the United Nations, the International Committee on Space Research (COSPAR), and the European Space Research Organization (ESRO).

Through personnel exchanges, education, and training efforts, over 1,900 foreign nationals from 60 countries visited NASA facilities for discussions or general orientation. Thirty-three graduate students from 11 countries studied space sciences at 16 American universities. Forty-nine postdoctoral and senior postdoctoral associates from 19 countries performed research at NASA centers. And 48 technicians from 3 countries and ESRO, here at their own expense, received space technology training at three NASA installations.

Grants and Research Contracts Activities

Under NASA's Sustaining University Program, 886 predoctoral graduate students continued space-related training. Supplemental grants were made to 88 institutions and new grants to an additional 43. Under all these, 1,071 new graduate students were to begin training in the fall of 1964.

New research facilities grants went to 5 institutions, making a total of 20 to date. The five new facilities are to be an Activation Analysis

Center at Texas A. & M. University, a Space Sciences Center at the University of Maryland, a Space Science and Technology Building at Rice University, the Arthur Holly Compton Research Laboratory of Physics at Washington University (St. Louis), and a Space Sciences and Technology Center at the Georgia Institute of Technology.

As part of the research aspect of the Sustaining University Program, work began at five universities under previous grants. Extensions to grants were given to 15 institutions, and new grants to 7 others.

Through the Resident Research Associate Program, about 60 scientists held appointments at Goddard Space Flight Center, Ames Research Center, and Marshall Space Flight Center. The Lewis Research Center and the Manned Spacecraft Center are expected to participate during the coming year.

Informational and Educational Programs

Scientific and technical information activities and services were expanded to match a rising flow of research results and immediate program needs without proportional cost increases by increasing inhouse productivity and adapting new and improved methods and techniques.

The Agency helped more than 200 colleges and universities plan space science courses, provided summer workshop services for about 10,000 teachers, and engaged in adult education projects to increase public understanding of the Nation's space effort. NASA's spacemobile lecture-demonstration teams provided information on space sciences and exploration to more than 1.5 million school children, teacher training programs, and civic groups; spacemobile lecturers made television appearances for over 6 million viewers.

Other programs provided nontechnical publications, films, radio and TV presentations, and exhibits for professional, scientific, and technical audiences and the general public; speakers at meetings of professional, civic, and other groups; and advisory services and program assistance on space science and technology for educational organizations at all levels in nearly every State. NASA also participated in, sponsored, and cosponsored aerospace conferences for professional, scientific, and technical groups.

Personnel, Management, Procurement, and Support Functions

In the personnel field, NASA acted to implement the Governmentwide Employee-Management-Cooperation-in-the Federal-Service program. The Agency also continued to conduct numerous seminars and training programs for its employees (including seminars on procurement management and on incentive contracting, courses on supervisory training and on management development, and training programs on cooperative education and on apprenticeship).

During the period, the personnel force rose from 30,069 to 32,499 with almost 900 of the increase going to the Manned Spacecraft Center as its facilities became available for occupancy. Six new key executive appointments and five reassignments strengthened the Agency's administrative/management structure. In addition, during the first half of 1964, the Agency presented a number of awards and honors in recognition of special accomplishments and contributions of both individuals and groups.

Following recommendations of the Inventions and Contributions Board, the Agency granted petitions for 37 patent waivers, and made 3 awards for scientific and technical contributions and 53 awards for patentable inventions by NASA employees.

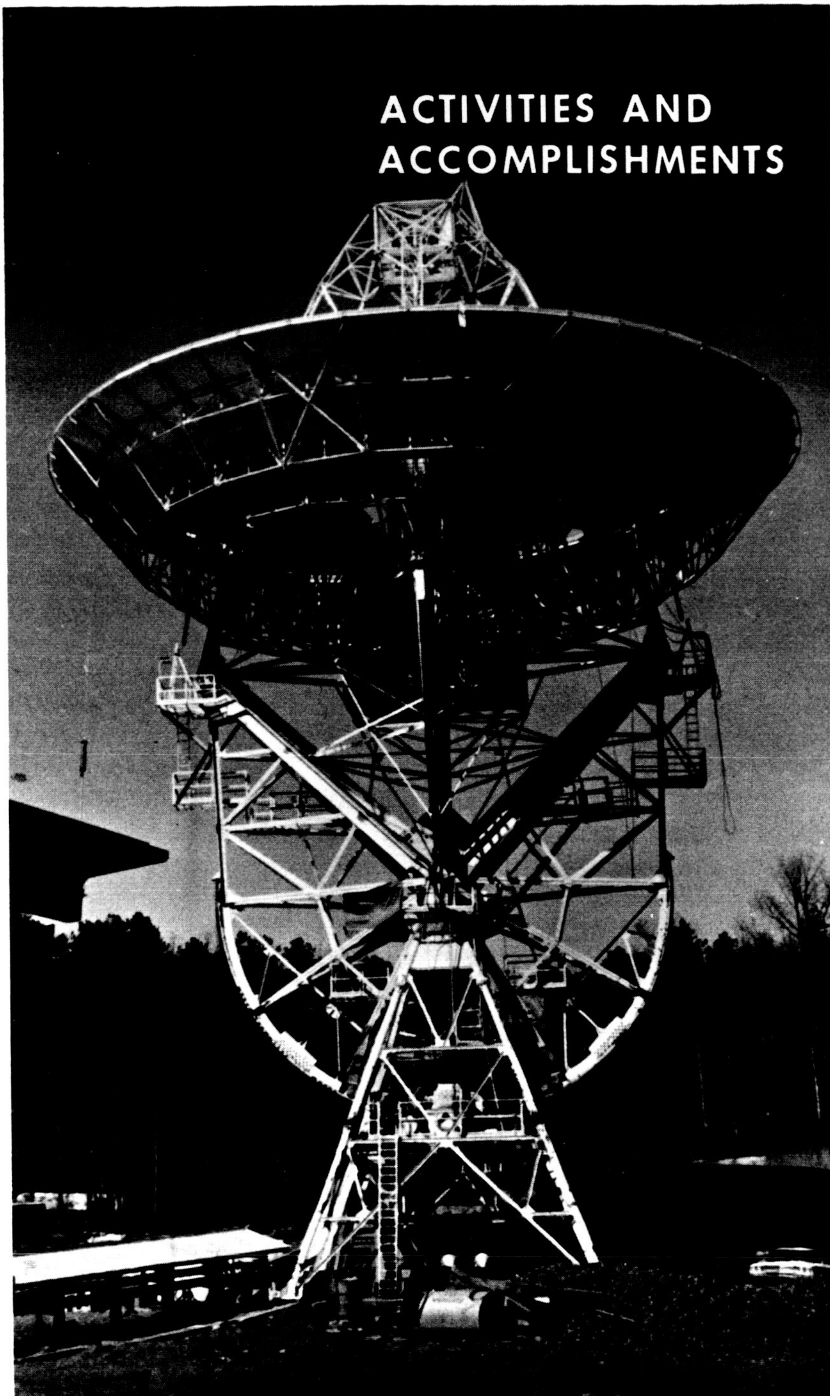
Further supplementing the agency-wide reorganization of November 1, 1963, NASA appointed an executive secretary to maintain proper flow of information between general management and other elements of NASA headquarters; documented and defined its basic administrative policies; and improved the alinement of the John F. Kennedy Space Center organizational structure.

Procurement and supply management functions continued to be improved. Increased emphasis on incentive contracting produced results to the point that by May of this year, there were 38 incentive contracts with a total target value of $353,567,781. Other actions were being negotiated. Also, steps were taken to improve the methods of obtaining negotiated overhead rates.

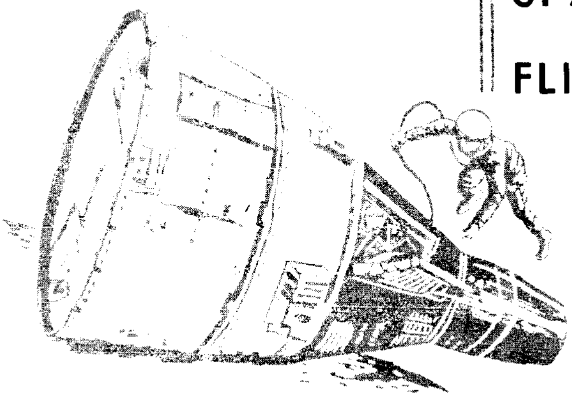
NASA's procurements for the period totalled $2,643 million. About 78 percent of the net dollar value was placed directly with business firms and 3 percent with educational and other nonprofit institutions. Overall, about 94 percent of NASA's procurement dollar was contracted to private industry. Small business firms received 7 percent of NASA's direct awards to business, and about 17 percent of the awards to large business were being subcontracted directly to small business.

The Agency continued to place great emphasis on the technology utilization program. Steps were taken to improve the flow of technical information to potential users. Also, in this area, cooperation with other Federal agencies was expanded.

ACTIVITIES AND ACCOMPLISHMENTS



I MANNED SPACE FLIGHT



Manned space flight activities increased in intensity during this period. Four successful major launches brought to 16 the total of consecutive major launch successes over a period of 3 years and 2 months. These flights included six in the Mercury program, one in the Gemini program, six in the Apollo-Saturn I program, two Apollo spacecraft tests, and a development flight of the Apollo-associated Little Joe II booster.

These launches demonstrated the broad basic operational capability being developed in the manned space flight effort, one that would be available to the Nation for many years to come. Elements of this capability include scientific, engineering, technical, and other personnel; industrial capacity; manufacturing, test, and launch facilities; launch vehicles and spacecraft; operational know-how; and the ability to manage a large research and development program.

In constructing the broad base of facilities required for the manned space flight effort, the peak had already been passed, and many major test, launch, and other installations were already in use. Others were nearing completion.

Of major significance during the reporting period were the first two meetings of the Science and Technology Advisory Committee for Manned Space Flight (STAC), which was organized in December

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1963. The committee met in March and June to provide from an independent source advice to the Associate Administrator for Manned Space Flight on the scientific and technological content of the program and on methods of obtaining maximum use of scientific and engineering talent and knowledge.

THE GEMINI PROGRAM

A major milestone in the Gemini program was passed on April 8, 1964, when the program entered the flight phase with the first flight test of the Gemini Spacecraft/Titan II Gemini launch vehicle.

A new management capability was provided by the establishment of the NASA/Industry Gemini Executives Group. Substantial progress was made by contractors in the manufacture of spacecraft, launch vehicles, and the Agena target vehicle. The comprehensive testing program neared its final phases.

Mission planning moved forward rapidly. Astronaut training intensified, with the selection of the primary and backup crews for the first manned flight. Special emphasis was placed on the development of scientific experiments, while substantial advances were made in the space medicine program.

NASA-Industry Gemini Executives Group

To further strengthen the Gemini management structure, a NASA-Industry Gemini Executives Group was organized. Members of this group, totaling eight, consist of the Associate Administrator for Manned Space Flight, key NASA officials, chief executives of the four major contractors involved in the Gemini program, and an Air Force representative.

The function of the group is to improve communications and rapport between top management of NASA and major contractors by providing company executives the program perspective they require and obtaining from them knowledge about their frontline problems. The group met in March, May, and again in June.

Gemini Objectives

The Gemini program is the second major step by the United States in manned space systems development and space exploration. It follows the pioneer efforts in Mercury and prepares the way for Apollo. Two-man earth orbital flights early in the program will lead to long-duration flights and rendezvous-docking flights in later phases.

The basic objectives of Gemini are to increase the operational proficiency and knowledge of the technology of manned space flight. Two major mission objectives have been established. One is long-duration flight, up to 2 weeks—longer than required for an Apollo lunar mission. The second is to achieve and become proficient in rendezvous and docking operations—during which the spacecraft and a target vehicle will be joined while in orbit.

Associated operational objectives include: Maneuvering in space after docking; performing controlled reentry; conducting extravehicular activities; landing at a preselected site; and accomplishing a number of scientific and technological experiments. Knowledge gained during the Gemini program will contribute substantially to the Apollo program and to the manned space flight program of the Department of Defense.

Development and Testing

Gemini flight systems consist of the Gemini spacecraft, the Gemini launch vehicle (an Air Force Titan II ICBM specially modified and "man-rated" for greater reliability and astronaut safety), an Agena target vehicle, and an Atlas booster for the Agena.

One of the highlights of the reporting period was the beginning of flight tests to develop the capability for long-duration and rendezvous missions. In the meantime, the extensive ground testing of the two-stage Gemini launch vehicle and the spacecraft continued. The first flight test (GT–1) revealed the effectiveness of the "man-rating" of the Titan II and the earlier testing of the launch vehicle. It was an unmanned orbital flight without planned recovery. The primary objective was to demonstrate the structural integrity of the Gemini spacecraft and its compatibility with the Gemini launch vehicle.

After an uninterrupted countdown at the John F. Kennedy Space Center's Launch Complex 19, the 65-orbit flight began.

The spacecraft was a partially equipped configuration of the reentry module and the adapter section, the latter consisting of equipment and retrograde rocket sections. It carried a telemetry system, sensors, and ballast plates. The object was the second heaviest launched into earth orbit by the United States at the time, exceeded only by the Saturn I shot on January 29.

The radio guidance system of the second stage, one of the major modifications to the Titan II launch vehicle, performed as planned. Telemetry data was complete and of excellent quality. In all respects, the test was highly successful.

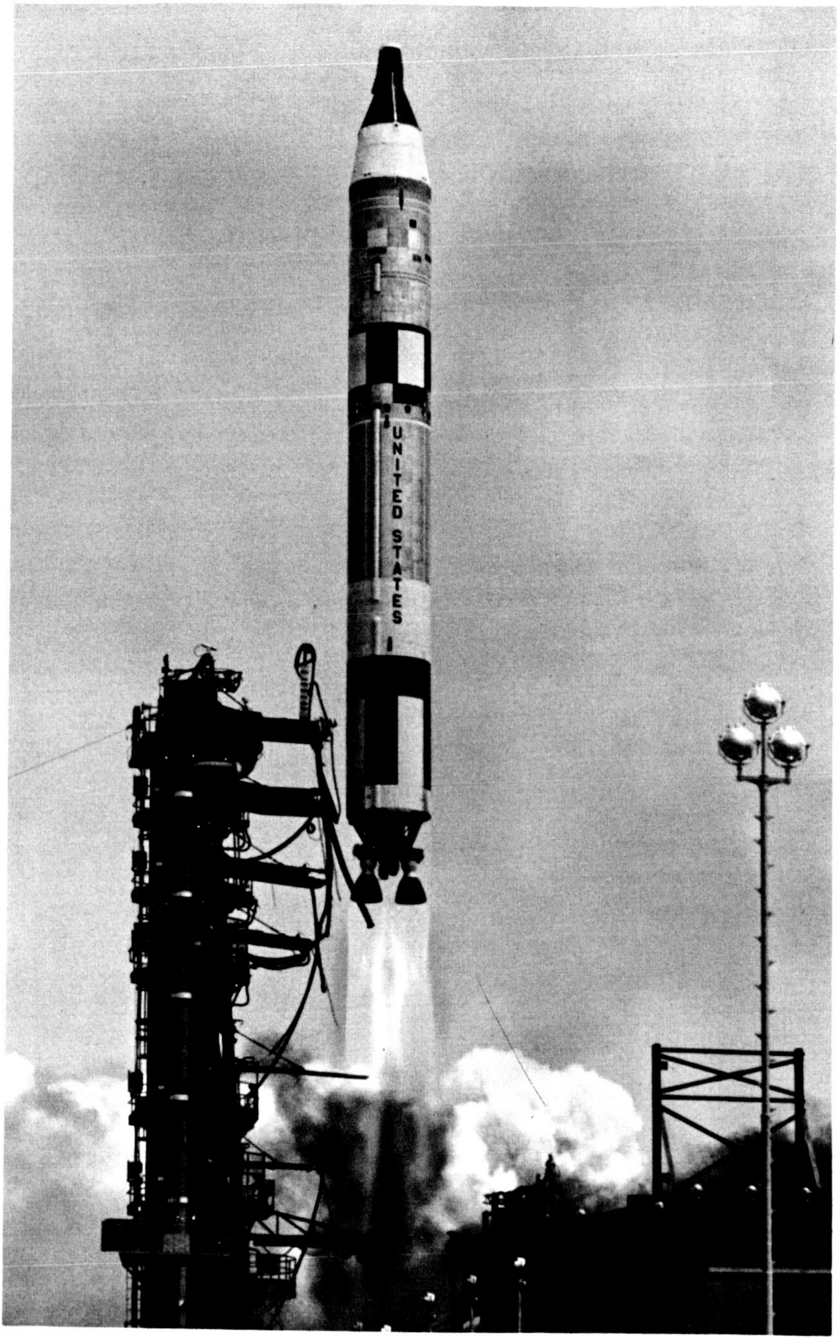

Figure 1–1. Gemini-Titan II liftoff for first flight test.

Spacecraft.—In June spacecraft No. 2, for mission GT–2, was in the systems test phase at the contractor's plant, being prepared for delivery in the next quarter to the John F. Kennedy Space Center. By the end of June, construction of spacecraft No. 3, for the first manned Gemini mission, was essentially completed and some overall systems checks had been made. The front view of this spacecraft is shown in figure 1–2.

After the design and development engineering inspection, only 17 changes were ordered, most of them relatively minor.

Spacecraft Nos. 4 through 9 were well along in fabrication with spacecraft Nos. 4 and 5 entering the test phase later this year. Components of subsequent spacecraft were also being fabricated.

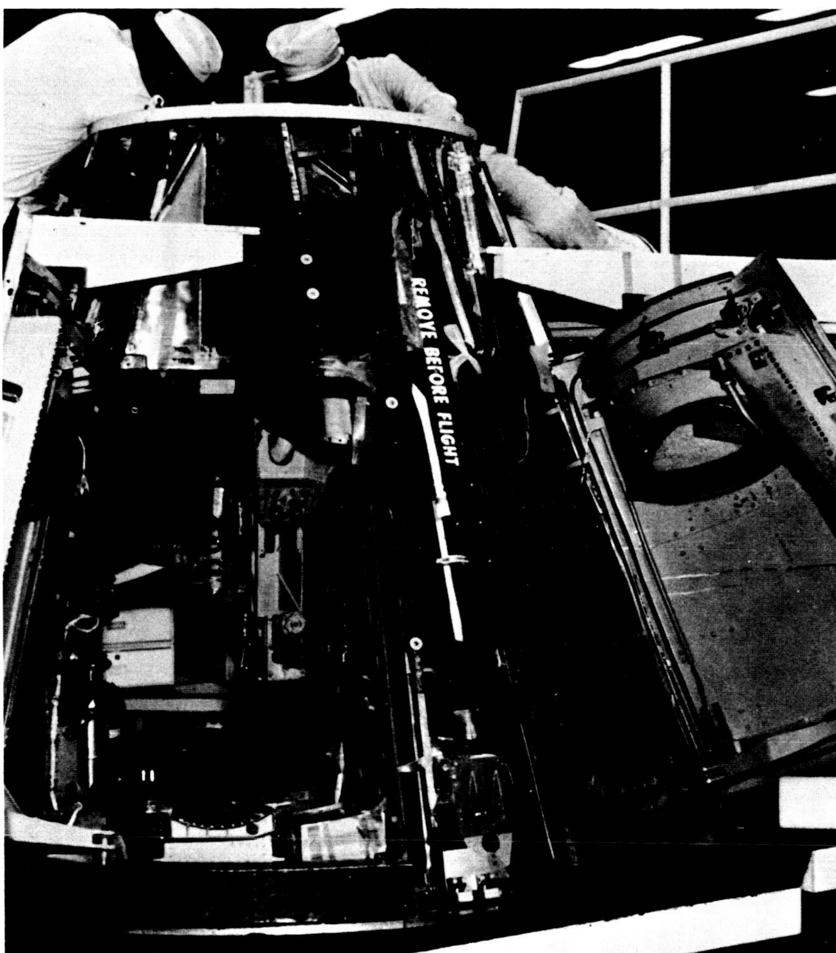

Figure 1–2. Front view of Gemini Spacecraft No. 3.

The structural and recovery systems tests to qualify the spacecraft for manned space flight continued throughout the period. Rigorous qualification tests were performed on both the adapter and the reentry module to simulate different launch and reentry conditions. Water landing impact tests were conducted to qualify the structure for all conditions that the spacecraft might encounter during landing.

Recovery systems tests were also conducted. Several drops were made with the 18-foot pilot and 8-foot drogue parachutes, using the planned test sequence with two of the nonflying test spacecraft. Flotation and egress tests were conducted in Galveston Bay with a test spacecraft and astronaut. Sled tests for the development and qualification of ejection seats also continued. The first qualification run on the seats was conducted in June and the remaining tests were to be performed during the remainder of the year.

Test articles of the various subsystems were subjected to intensive development, qualification, reliability, and systems testing to qualify them for the first manned mission.

Launch Vehicles.—Development and manufacture of the Gemini launch vehicles progressed smoothly. Continuing research and development flight tests of the Titan II, conducted by the Air Force, were regularly monitored by NASA for applicability to the Gemini launch vehicle.

In carrying out the "man-rating" program, the contractor had instituted special procedures as well as design changes. Stringent controls were exercised throughout the design, development, manufacture, and test of critical components to insure reliability. Prime spare parts were also specially selected, "man-rated," and procedures set in motion to make certain that they were available in adequate quantities.

The launch vehicle component, subsystem, and combined systems testing programs were also stringent. In addition to the ground testing, such Gemini components as the malfunction detection system were tested on Titan II ICBM research and development flights.

Manufacturing methods were continually monitored to assure compliance with standards and to prevent component damage. (In addition, each vehicle undergoes a "rollout" inspection.)

The most important element in establishing and maintaining "man-rating" standards is human performance. To assure high performance, the contractor carried out a special program to certify that all individuals involved with testing the launch vehicle were technically fully competent in the system on which they were working. To qualify, a worker had to complete successfully a Gemini training course or courses pertaining to the system on which he was working and an individual or crew job performance evaluation.

For the Gemini program, 15 launch vehicles were being procured for NASA by the Air Force Space Systems Division (AFSSD). One was used for the GT–1 mission. Of the remaining 14, 2 had already been produced by the end of June and manufacture of the others was progressing well.

Gemini launch vehicle (GLV) No. 2 (Mission GT–2) had been erected at Launch Complex 19, John F. Kennedy Space Center, and final checks were being made. Launch vehicle No. 3 (Mission GT–3, first manned mission) had been erected at the contractor's plant for systems testing prior to shipment to the Center. (See fig. 1–3.)

The fourth launch vehicle was in assembly and horizontal test which precedes checkout in the vertical test facility. The tanks for No. 5 were delivered to Baltimore from Denver, Colo., and were being cleaned prior to splicing. Components for additional vehicles were in various stages of manufacture.

Atlas/Agena Target System.—The complete Gemini target system, to be used in rendezvous and docking missions, consists of a modified Agena D and an Atlas standard launch vehicle. As stated in the *10th Semiannual Report*, the Atlas/Agena target vehicle systems are being procured through the Air Force Space Systems Division.

Atlas.—The Atlas standard launch vehicle was being further improved by the Air Force to increase reliability and flexibility during countdown and launch. NASA is contributing development funds to the improvement program.

Agena.—The modifications to the basic Agena D, described in the *10th Semiannual Report*, will provide for additional maneuverability in orbit; for command and communications compatible with the Gemini spacecraft and the ground station network; and for docking with the spacecraft.

The Agena development started later than the Gemini spacecraft and launch vehicle because the Agena is not required until the first rendezvous flight in late 1965. Agena modification design was finished in 1963, and development and qualification testing are planned for completion in early 1965.

During this reporting period, Agena passed several major milestones, including acceptance and delivery of the first for modification to the Gemini configuration. The preliminary flight rating tests for the Agena main engine were essentially completed and well along on the secondary propulsion system. Both engine systems were installed in a boilerplate type of vehicle (Propulsion Test Vehicle Assembly) for mission simulation tests. (See fig. 1–4). The first of these tests were conducted successfully. Development work continued in some electronic areas, particularly on the Command Programer. Modification of system checkout equipment neared completion. All elements

Figure 1–3. Second stage of GLV No. 3 in vertical test facility.

of the Gemini target vehicle program thus moved in good order toward the planned launch dates.

Mission Planning

During the first half of calendar year 1964, along with the first Gemini mission (GT–1), flight operations effort included detailed planning for the remaining eleven Gemini flight missions and the

Figure 1–4. Agena Propulsion Test Vehicle Assembly ready for test.

completed documentation of this planning for GT–2. Monthly panel meetings at the Manned Spacecraft Center coordinated among the flight operations, flight crew operations, medical organization, and the Gemini Program Office. (These meetings are necessary to pool the efforts of all the diverse organizations which form the operations organizations during a mission period.)

The completed documentation for GT–2 includes formal data acquisition plans, missile rules, the flight plan, launch area recovery plan, and operational support requirements. Details for coordinated countdown and launching of the Gemini and Atlas/Agena within the time limits of the launch window for a rendevous mission were approaching completion.

The Mission Control Center and the Tracking Network successfully supported the first Gemini Mission. (See fig. 1–5.) The specifications for the control center and network requirements for GT–2 were completed, and these systems are to be exercised prior to the mission. NASA will accept the Manned Space Flight Control Center (previously designated IMCC), from the contractor early in 1965, insuring its readiness to support the first rendezvous mission later in the year.

The first Gemini Mission (GT–1) was considered successful in all respects. The spacecraft was launched within one second of schedule and tracked throughout the life of its active beacons by the Manned Space Flight Network. The computer center at Goddard Space

Figure 1–5. Operations control room, Cape Kennedy Mission Control Center.

Flight Center tracked the spacecraft after loss of power in the spacecraft and accurately predicted its reentry into the South Atlantic.

The second Gemini mission (GT-2), scheduled late in 1964, will be a suborbital flight to validate the spacecraft systems from launch through reentry.

Astronaut Training

As the time neared for the first manned flight in the Gemini program, the primary and backup crews for the flight were named, and advanced specialized training was intensified. In the meantime, the 14 new astronauts who reported in February completed their academic training in science and technology and started specialized training for both Gemini and Apollo flights.

Named on April 13 as the primary crew for the first manned flight (GT-3) were Maj. Virgil I. "Gus" Grissom, command pilot, and Lt. Comdr. John W. Young, copilot. Grissom had been responsible for coordinating all Gemini developments with the other astronauts. The backup crew consisted of Lt. Comdr. Walter M. Shirra, Jr., command pilot, and Maj. Thomas P. Stafford, copilot. As tentatively planned, the backup crew would be substituted as a team in the event that either of the primary pilots is grounded.

During the reporting period, these four astronauts frequently visited the contractor's plant in St. Louis, where Gemini spacecraft were being manufactured. They received training in the spacecraft and participated in other exercises, including preliminary use of a Gemini spacecraft docking simulator (Translation and Docking Trainer) which was being readied for shipment to the Manned Spacecraft Center.

Three astronauts—Neil A. Armstrong, Lt. Comdr. James A. Lovell, Jr., and Maj. Thomas P. Stafford—took part in water egress and other tests. These were the first conducted under actual sea conditions (in Galveston Bay). Using a model of the Gemini spacecraft, they developed techniques that would later be taught to the other astronauts. Tests were made with and without a flotation collar (a rubber raft inflated around the spacecraft by pararescue teams at the end of a mission). Earlier, the astronauts had practiced egress from the capsule in a huge tank at Ellington Air Force Base and in the training tank at the Manned Spacecraft Center.

In May the Manned Spacecraft Center conducted a 10-day series of weightlessness tests, using a Gemini spacecraft installed inside a KC-135 jet aircraft. Astronaut John W. Young took part in the tests along with Air Force and contractor test pilots.

The 14 new astronauts, selected in October 1963, were Edwin E. Aldrin, Jr., major, USAF; William A. Anders, captain, USAF; Charles A. Bassett II, captain, USAF; Alan L. Bean, lieutenant, USN; Roger B. Chaffee, lieutenant, USN; Eugene A. Cernan, lieutenant, USN; Michael Collins, captain, USAF; R. Walter Cunningham, civilian; Donn F. Eisele, captain, USAF; Theodore C. Freeman, captain, USAF; Richard F. Gordon, lieutenant commander, USN; Russell L. Schweickart, civilian; David R. Scott, captain, USAF; and Clifton C. Williams, captain, USMC.

In June, after formal classroom academic training, they began advanced training. This training includes rides on the centrifuge at Johnstown, Pa., weightlessness flights in a KC–135 aircraft, desert and tropical survival training, ejection seat rides, helicopter training, parachute jumping, and hours of studying the Gemini and Apollo spacecraft. In the first phase, they participated in a training exercise at the Air Force's tropical survival school in Panama. They were accompanied by fellow astronaut Charles "Pete" Conrad, who had completed this course in 1963.

Space Medicine

Principal space medicine activities in the Gemini program during the reporting period centered on crew equipment, pressure suits and life support systems, biomedical experimental studies, and medical flight operations.

Fabrication of the urine transport system was completed and flight qualification tests were begun. The design of a first-day urine collection device was established and a prototype developed. Food and packaging design was nearing completion. Food, water, and waste systems Nos. 3, 4, and 5 were delivered by the subcontractor to the prime contractor for the spacecraft.

The contractor delivered the intravehicular (inside the spacecraft) training suit to the Manned Spacecraft Center and evaluation and flight qualification began. A contract was awarded for the GT–3 flight suit and fabrication was initiated. It was also decided to proceed with a contract for the extravehicular suit, which will be worn outside the spacecraft on later missions. A contract was also awarded for extravehicular life support systems, and preliminary analysis and design were initiated.

Bioinstrumentation development (including body temperature instrumentation, impedance pneumograph, heart action, blood pressure instrumentation, and biomedical research instruments) was nearing completion. Prototype survival equipment was evaluated by the

Manned Spacecraft Center, contracts awarded, and equipment fabricated and delivered for flight qualification.

Other space medicine activities, for missions GT–3 through GT–7, included the completion of selected contract and in-house studies of stress during long-duration flight; initiation of hardware development for medical inflight experiments; establishment of medical data plan requirements; initiation of medical data evaluation from mission simulations; development of preliminary medical mission rules; determination of flight medical objectives; development of preliminary flight medical plan; operational evaluation of medical flight experiments; definition of components of flight data analysis plans; submission of medical recovery requirements to the Department of Defense; and preparation of the medical monitoring plan.

Scientific Experiments

Vitally important aspects of the Gemini and Apollo projects are the scientific experiment programs. To facilitate planning for these programs, a Manned Space Flight Experiments Board, established late in 1963, was formally organized on February 10, 1964. Consisting of nine key NASA and associated personnel, it considers scientific, medical, technological, and engineering experiments submitted by the scientific community, other agencies of the Government and NASA offices; it then makes recommendations to the Associate Administrator for Manned Space Flight.

During the reporting period, these efforts were intensified for Gemini, and by the end of June, the Experiments Board had approved 41 experiments for missions GT–3 through GT–12. Seventeen of which were technological, 12 were scientific, 9 were medical, and 3 were Manned Spacecraft Center special engineering experiments. Some would be repeated during the Gemini missions.

Also by the end of June 1964, the principal investigators for these experiments—scientists from universities and various laboratories—had begun making the necessary preparations for testing. Appropriate modifications to the various spacecraft were being planned and, in some cases, had already been accomplished. Flight qualification testing of the experimental equipment slated to be used on the first manned Gemini mission (GT–3) was begun in June.

Though experiments for the early Gemini program were quite firm, some opportunities existed for research experiments and studies beginning in 1966. For this reason, and to insure the broadest and best possible selection, NASA's Office of Space Science and Applications requested domestic and foreign scientists to submit proposals for experiments for Gemini flights GTA–10, GTA–11, and GTA–12. Priority was to be given to experiments particularly important to the follow-on Apollo program.

The Apollo Program

In the Apollo program, major strides were made in hardware manufacture and testing, construction of facilities, mission planning, space medicine, and planning and preparing for the conduct of scientific experiments. Overall program management was solidified. To maximize scientific returns from the program, plans were made to recruit scientist-astronauts, and the scientific training of astronauts was intensified.

Apollo Objectives

The major objective of the Apollo program is to achieve U.S. preeminence in space during this decade through the creation of the broad range of capabilities required to accomplish manned lunar exploration. The returns from the investment in Apollo will include the flight hardware required for a broad foundation of operational capability in space and the associated technology; a valuable complex of developmental, test, and operational facilities; a trained Government and industrial team; operational skills; and the ability to manage large-scale research and development. All will open the door to the further exploration and exploitation of space as required by the national interest.

Specific Apollo flight program objectives include unmanned earth orbital qualification flights; manned earth orbital flights, including long-duration and rendezvous-docking missions; unmanned orbital qualification flights; orbital lunar mission simulation; and lunar landing and exploration.

Mission Planning

By June of 1964, general mission planning was well along and specific missions were beginning to be formulated.

The Saturn I phase of the program involved mainly earth orbital testing of boilerplate command and service modules, micrometeoroid experiments, development of the first stage of Saturn IB, and development of liquid-oxygen/liquid-hydrogen technology for use in the Saturn IB and Saturn V phases. This phase would give the Nation the firm technical base upon which to develop the more powerful vehicles essential to manned exploration.

The initial flights on the 12-flight Saturn IB program were planned for launch vehicle and spacecraft heat shield development. These space vehicle qualifying flights are to be followed by manned earth orbital missions, during which rendezvous and docking techniques necessary for the lunar mission would be developed. Manned long-duration earth orbital missions would also be conducted to test astronauts and systems under extended periods of weightlessness. In addition, the liquid-hydrogen fueled J–2 engine, used in the upper two stages of the Saturn V, would acquire much flight test time.

The 15-mission Saturn V program would include early unmanned flights for launch vehicle development and spacecraft heat shield verification at the expected lunar return reentry speed. Manned lunar missions would follow the space vehicle qualification flights. The objectives of the lunar flights would be to land men on the lunar surface, have them make scientific investigations, and return them safely to earth.

Systems Engineering

Systems engineering emphasis in Apollo shifted somewhat from broad specifications and plans to studies of particular problem areas where there were systems interactions. These studies included computer simulation studies and model drop tests. This shift occurred because of the general transition of the Apollo program to a system development phase.

Detailed studies were completed on meteoroids, solar radiation, and lunar soil mechanics. A preliminary study on lunar landing constraints was completed and further studies of systems required for landing site certification were underway.

Development and Testing

To accomplish the objectives of the Apollo program, launch vehicles must be developed and qualified for manned flight. A highly reliable spacecraft must be developed that is capable of supporting man in space for periods of 2 weeks, docking (coupling) in space, landing on the lunar surface, and safely reentering the earth's atmosphere at 36,000 feet per second within a precise reentry corridor.

The equipment reliability, thermal protection, and guidance accuracy requirements exceed those of the Gemini program and are many orders of magnitude beyond those of the successful Mercury program. Extensive development and testing are necessary.

In the reporting period, two highly successful flight tests of the Saturn I (fig. 1–6) occurred during the reporting period. The first of these, on January 29, 1964, took place 6 years (less 2 days) after the launching of the first U.S. satellite, Explorer I, which weighed only 31 pounds. In this fifth in a series of 10 planned flights, the Saturn I hurled 37,700 pounds (including the second stage) into orbit, or a thousand times more than Explorer I, for an expected lifetime of more than 500 days. The payload capability of the Saturn I vehicle is over 10 tons—considerably greater than ever claimed to have been orbited by the Soviet Union.

SA–5 also scored an impressive number of "firsts": The first flight from Launch Complex 37 at the John F. Kennedy Space Center; the first Saturn I flight in which both the first (S–I) and second (S–IV) stages were live; the first Saturn I flight using liquid-oxygen/liquid-hydrogen (second stage) as a propellant and only the second NASA flight test of this propellant (the first test was with the Centaur, November 27, 1963); the first launch with the S–I stage H–1 engines uprated from 165,000 to 188,000 pounds; the first flight test of the instrument unit; and the first Saturn I orbital mission.

During the flight, eight onboard motion picture cameras photographed various operations of the rocket and a television camera provided realtime photographs of separation and ignition of the S–IV stage. Motion picture cameras were mounted at the forward end of the S-I stage in eight separate pods, which were ejected by high-pressure nitrogen 25 seconds after first-stage separation. Parachuted to the surface, they floated until recovered.

The timing of all significant actions in the launch sequence varied no more than half a second from prediction. The test further proved the capability of the first stage, checked the separation of the first and second stages, and tested the function of the S–IV stage liquid-oxygen/liquid-hydrogen system.

In addition, SA–5 gave all the major ground tracking networks of the United States—NASA, the Department of Defense, and the Smithsonian Astrophysical Observatory—a chance to participate in a global tracking exercise, one of the most extensive conducted to the time.

On May 28, 1964—about 4 months after the SA–5 launch—an even more sophisticated version of the Saturn I, the SA–6, was flown from Launch Complex 37. (See fig. 1–7.) It was the first to employ an unmanned boilerplate Apollo spacecraft (command and service modules) and the first to use the path adaptive active closed loop guidance system (ST–124). The total weight orbited (37,300 pounds) was the second heaviest to the time, exceeded only by SA–5. Telemetry results were excellent.

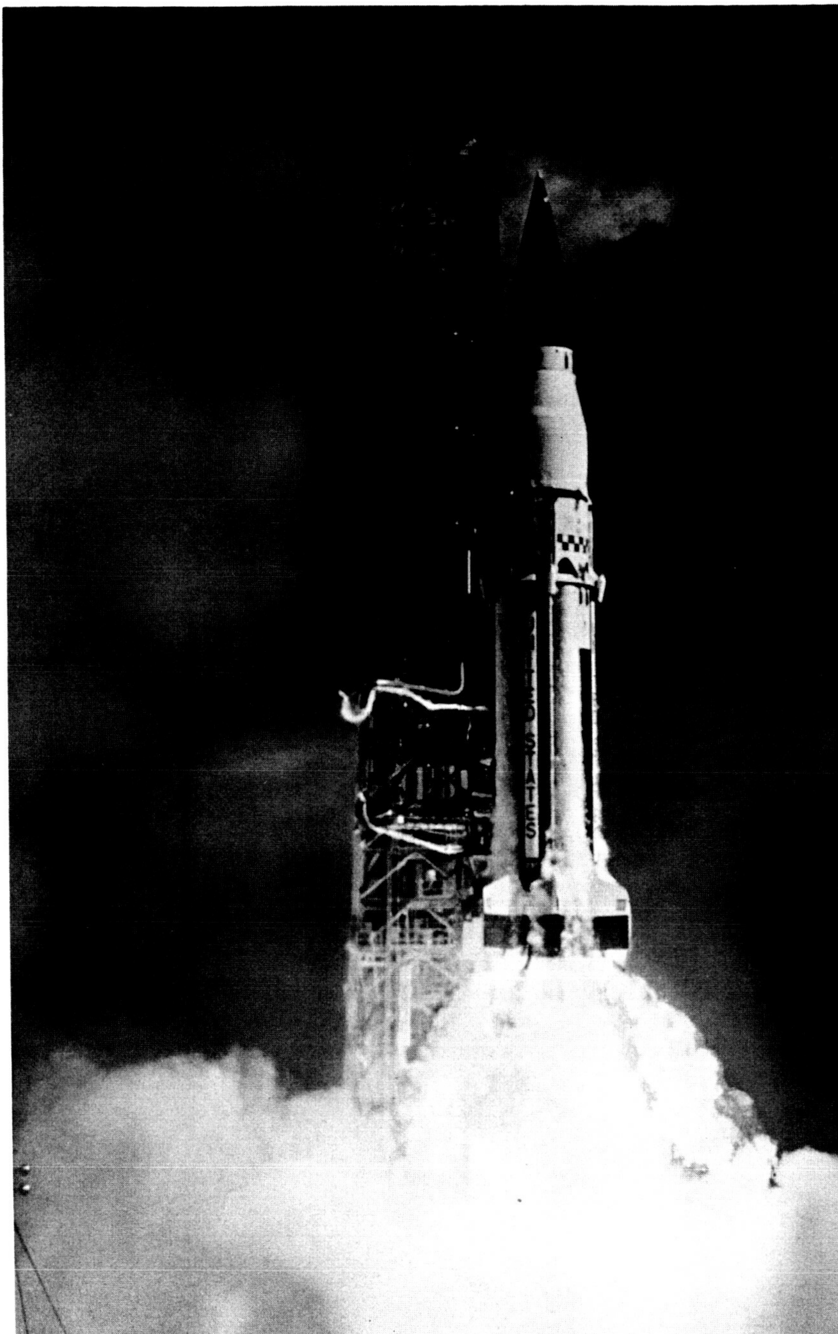

Figure 1–6. Fifth Saturn I launch.

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Figure 1-7. Sixth Saturn I launch.

An "engine-out" capability, which had been demonstrated during the SA-4 flight, made SA-6 a success despite early cutoff of one of the eight H-1 engines. Longer burning of the remaining engines and course corrections by the guidance system compensated for the loss and resulted in a near-perfect orbit.

All spacecraft operations occurred as expected. The launch escape tower was jettisoned shortly after first stage separation. All eight motion picture cameras were ejected and recovered.

The ST-124 stabilized platform was used actively for the first time for vehicle guidance during the second stage burning, thus qualifying it for full operational usage on SA-7 and subsequent flights.

At the end of June, preparations were well along for SA-7. The two stages and the instrument unit had been delivered to the John F. Kennedy Space Center, and the vehicle was being assembled and checked out. (See fig. 1-8.)

Spacecraft.—The Apollo spacecraft consists of three sections, or modules: The command module, service module, and the lunar excursion module.

The configuration of the command and service modules, well defined since mid-1963, underwent final review in the second quarter of 1964, during a mockup inspection. It included a review by astronauts, who performed task analyses under vented suit conditions for prelaunch and reentry phases.

Seven boilerplate test models and seven airframe vehicles were being manufactured during the period. (Airframes carry all systems in the final flight configuration, but boilerplates are built with a simplified, heavy structure and carry only those systems required for a specific test.) Development engineering inspections were conducted at the contractor's plant on boilerplate command and service modules which would be flown on the SA-7 Saturn I flight from Cape Kennedy, and on the second Little Joe II abort test at White Sands Missile Range.

The prototype fuel cell powerplant was successfully operated at required power output for the first time at the spacecraft contractor's facility. In the development test program, an Apollo fuel cell assembly passed 470 hours at required power output in a vacuum chamber. (See fig. 1-9.)

An Apollo boilerplate spacecraft was being prepared for integrated systems testing at the contractor's plant. Delivery and installation of the systems were well underway.

Suborbital flight testing of boilerplate spacecraft began May 13, 1964, with a successful transonic abort test at White Sands Missile Range, N. Mex. An unmanned command module was separated from the service module and booster by the launch escape system at an altitude at which aerodynamic stresses were great and lowered safely to the ground by the parachute system. The booster was the solid propellant Little Joe II. This was the second test in the series. The first, in the fall of 1963, triggered the escape system from a standing start on the launch pad.

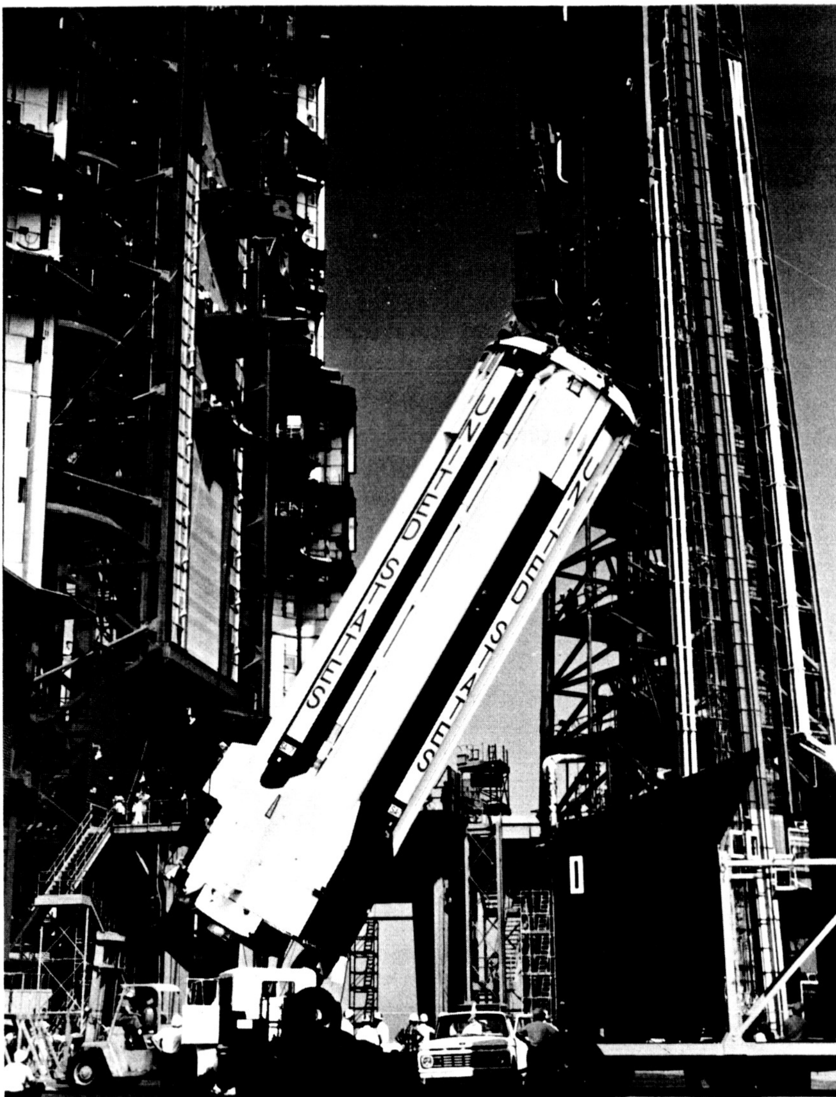

Figure 1–8. S–I stage being erected at Cape Kennedy.

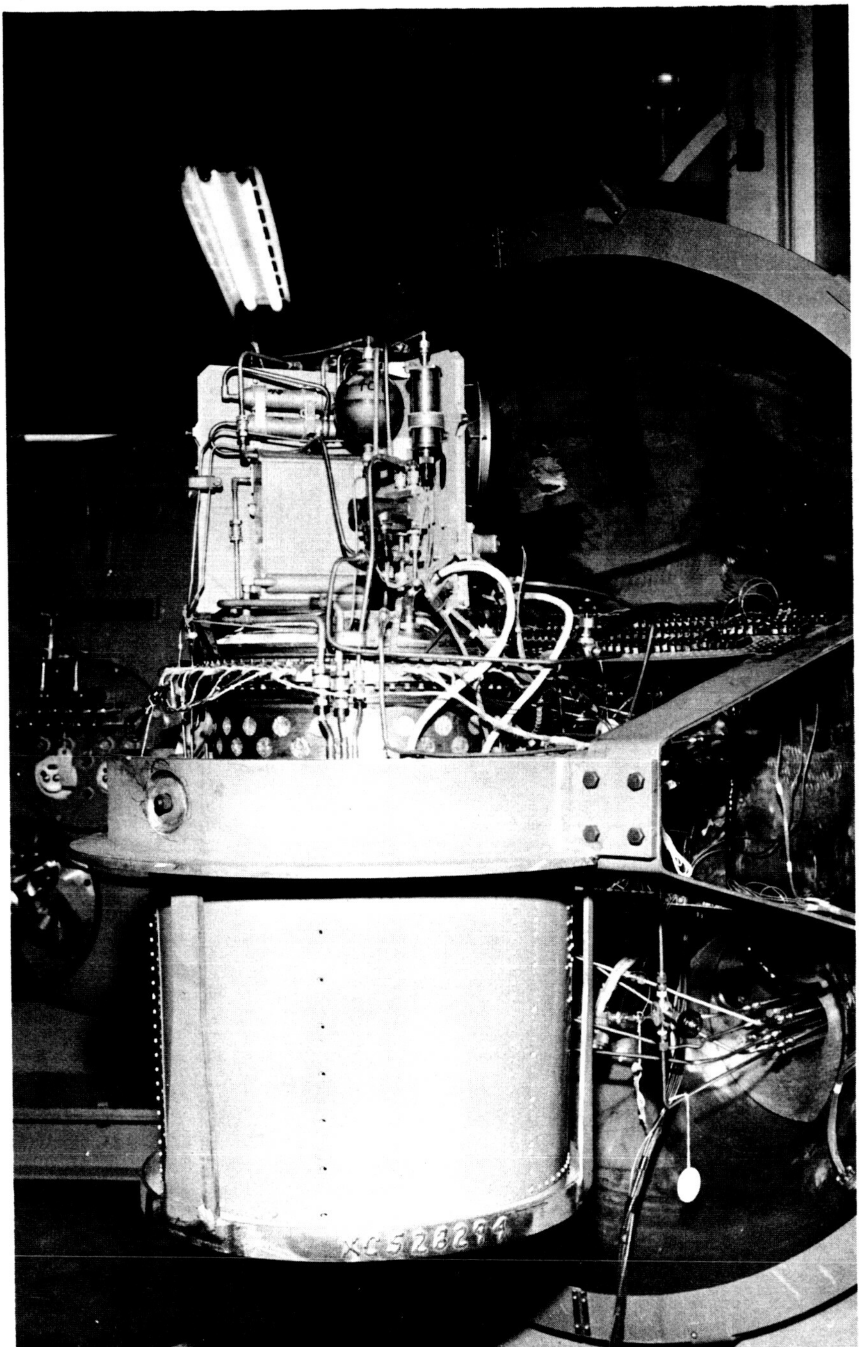

Figure 1–9. Prototype Apollo fuel cell mounted in vacuum chamber bell.

Besides the boilerplate command and service modules for the transonic abort test and for the SA-6 and SA-7 Saturn I flights, the contractor delivered boilerplate service modules to Marshall Space Fight Center during the period for use in the micrometeoroid experiments on the SA-8 and SA-9 flights. Command modules for these flights were nearing readiness for delivery.

Vehicle and subsystem development of the lunar excursion module (LEM) progressed satisfactorily during this period. Designs and configurations were essentially frozen and undergoing detail refinements. Major subcontractors were selected to develop the abort guidance section, ascent stage tanks, reaction control system tanks, rate gyros, attitude indicator, propellant gauging, cryogenic gas storage, and the LEM mission simulator.

Fabrication and assembly of the first LEM test model were completed, and a formal NASA review was held in March. (See fig. 1-10.) This test model was a full-scale replica in wood and plastic for use in evaluating crew visibility, crew mobility, and cockpit and equipment arrangement.

A LEM metal mockup was approximately 40 percent fabricated at the end of June. It will be used primarily in engineering design for locating equipment and line runs.

Two of the nine ground test vehicles were being fabricated. Marshall Space Flight Center will use one to obtain data on the dynamic effect of a LEM on the Saturn launch vehicle. The command and service module contractor will use the other to obtain data on the compatibility of the LEM and the adapter. The contractor would later begin fabricating 11 flight models.

Vehicle test effort started during this period included thermal tests on a descent stage structure and antenna tests on a full-scale model. Development tests were in progress on subsystems, including landing gear, propulsion systems, fuel cell assembly, and communications equipment.

Hardware items delivered during the period included a 1/6 scale landing stability test model to the Manned Spacecraft Center and a wooden mockup of the LEM to the command and service module contractor for adapter compatibility tests.

The guidance and navigation systems for the command module and the lunar excursion module were in an advanced state of development. Four systems had been fabricated and the first three were tested at the subsystem level in support of the design process. Tests included mechanical, electrical, and environmental evaluations.

The fourth system, the first to be integrated into a complete system, was used to evaluate functional operation, to study ground support equipment, and to develop and prove system test and operations procedures. It was then delivered to the spacecraft contractor for use in spacecraft/ground support equipment integration. An initial production run was started, the first systems being in the final acceptance phase at the end of the period.

A second block of improved guidance and navigation systems was being designed to include the unique requirements of the lunar excursion module. The systems for both modules will be functionally identical, differing only in packaging to fit the different spacecraft.

Among the major subsystems of the Apollo spacecraft are the three main propulsion systems, used in the service module, the LEM

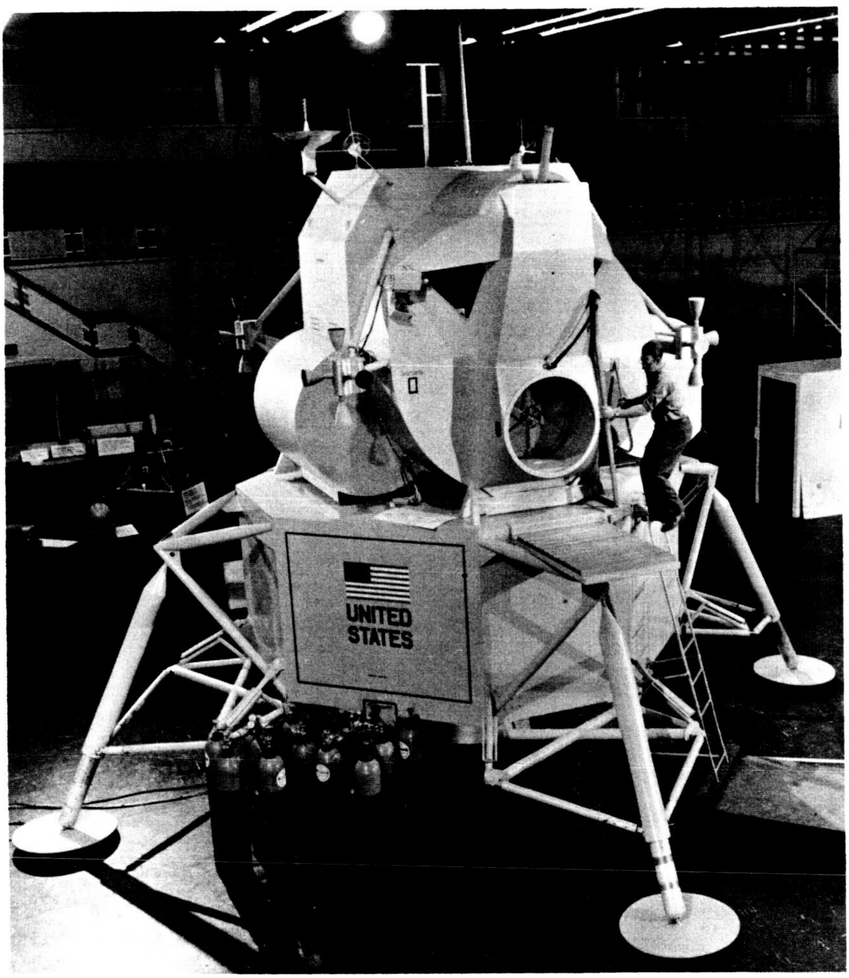

Figure 1–10. Mockup of Lunar Excursion Module.

descent stage, and the LEM ascent stage. In this development, the emphasis was on maximum reliability.

During this period, Phase I development of the service module engine was completed, including a program of altitude firings. During Phase II at the Arnold Engineering Development Center in the latter half of 1964, an injector designed to increase engine performance will be tested. The first ground test engine was delivered to the service module contractor, and preparations were being made for the initial firings at the Propulsion System Development Facility at the White Sands Missile Range.

Because of the advanced technology required to develop a reliable, controllable-thrust engine for lunar landing of the LEM descent stage, two contractors were engaged in a parallel development effort. (See fig. 1–11.) This engine will provide thrust which can be throttled from 10,500 down to 1,050 pounds. Components were developed through sea level testing and and were ready for altitude firing.

Considerable progress was made in developing the engine for LEM ascent. Two major components, the injector and the thrust chamber, began undergoing performance testing at altitude at the Arnold Engineering Development Center, Tullahoma, Tenn.

Sixteen 100-pound-thrust, radiation-cooled engines make up the service module reaction control system. They will be used for attitude control, propellant settling, and small velocity increments. Sixteen of those same engines are also used on the LEM. In fiscal year 1964, an improved injector configuration was designed to solve a persistent ignition pressure problem and provide a basis for completing the engine development.

Twelve 91-pound-thrust ablative engines in the command module reaction control system will be used during atmospheric reentry. An engine configuration was developed to meet performance and life requirements, and would soon start qualification tests.

Launch Vechicles

The Saturn I launch vehicle will be used to flight test Apollo boilerplate command and service modules. The Saturn IB will be used for Apollo unmanned earth orbital qualification and manned earth orbital flights. Saturn V is to be used for unmanned lunar orbital qualification flights, orbital lunar mission simulation, and, eventually, lunar exploration. The Little Joe II launch vehicle is being used for short-duration tests of the launch escape system and the earth landing system to simulate crew rescue from an abort situation early in the boost phase.

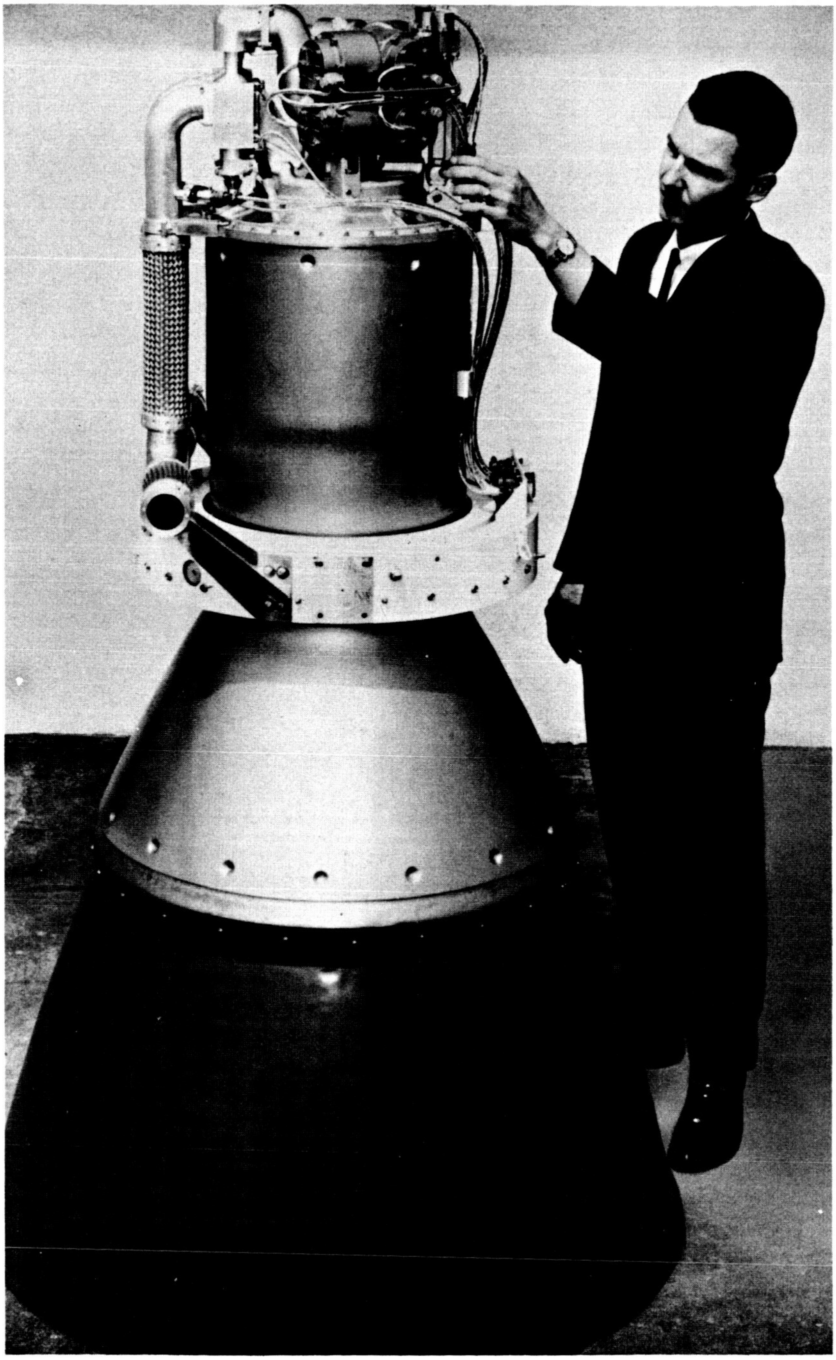

Figure 1–11. Mockup of LEM controllable thrust engine for lunar landing.

The Saturn I consists of an S–I first stage, powered by eight 188,000-pound-thrust H–1 engines; an S–IV second stage, powered by six 15,000-pound-thrust RL–10 A–3 engines; and an instrument unit. Manufacture and testing of Saturn I engines and stages were nearing completion at the end of the reporting period, 6 of the 10 scheduled Saturn I missions had been flown, and the seventh vehicle was being assembled and checked out.

All H–1 engines for the first stages had been delivered by the end of June; final deliveries of RL–10 A–3 engines had already been completed before the reporting period began, in December of 1963. The last two S–I first stages, being manufactured by a contractor at the Michoud Plant, were to be shipped by barge to the Marshall Space Flight Center for static testing prior to delivery to the John F. Kennedy Space Center.

The six S–IV stages were being produced by another contractor at Santa Monica, Calif., tested at the Sacramento Test Facility, and then transported to the John F. Kennedy Spacecraft Center. The last three stages were well along in fabrication.

The Saturn IB is a two-stage vehicle and is equipped with an instrument unit. The first stage, S–IB, is powered by eight H–1 engines, each uprated from 188,000 to 200,000 pounds of thrust. This provides a total thrust of 1.6 million pounds, compared with 1.5 million for

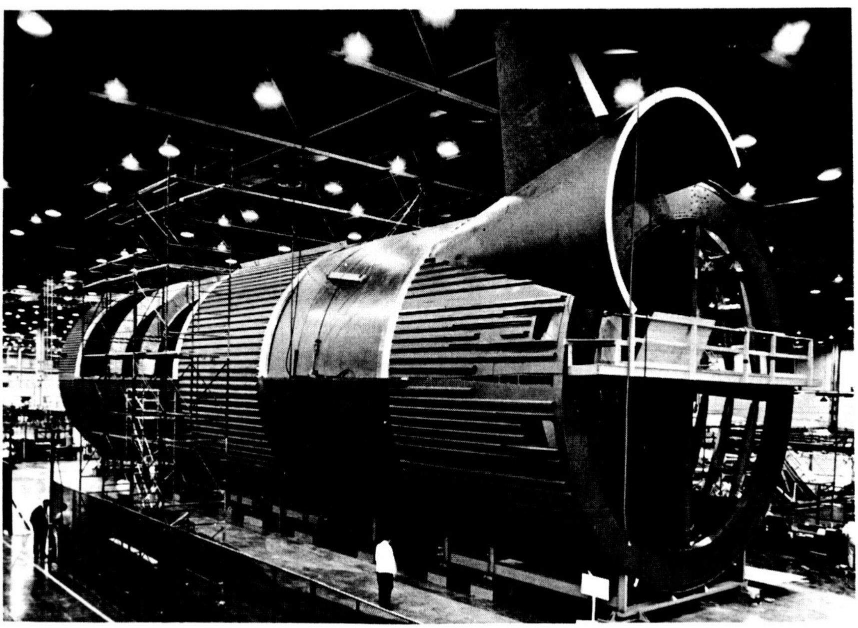

Figure 1–12. Mockup of the S–IC (Saturn V first stage) at Michoud Plant.

the S–I stage of the Saturn I. The second stage, S–IVB, consists of a single 200,000-pound-thrust liquid-oxygen/liquid-hydrogen J–2 engine in place of the six RL–10 A–3 engines used in the S–IV stage of the Saturn I.

During the first half of 1964, design and development of the Saturn IB vehicle continued on schedule. Fabrication and assembly of components for the first 2 of 12 booster flight stages were started by the contractor at the Michoud Plant.

In March, the contractor began delivering the Saturn IB H–1 engines to the Michoud Plant. Testing of hardware continued, component qualification testing at the 200,000-pound-thrust level being approximately 80 percent completed.

The S–IVB structural test stage was completed, and structural tests were initiated. The S–IVB battleship test stage was installed on the test stand and cold flow tests commenced. Fabrication of the first four S–IVB flight stages, manufacture of the facility checkout stage, and manufacture of the dynamic test stage were all underway. The same ground test stages will be used for both the Saturn IB and V test and development programs because the second stage of the Saturn IB also serves as the third stage for Saturn V.

In May 1964, the design for the instrument units was released. The units were being fabricated and assembled for the structural, vibration, and dynamic test programs, and for the first two flight units.

The three-stage Saturn V consists of the first stage, S–IC; the second stage, S–II; an upper stage, S–IVB; and an instrument unit. Initial designs of the stages were completed in May of 1964, and the design and development of the vehicles continued on schedule for the remainder of the reporting period.

At the Marshall Space Flight Center, the first two S–IC ground stages, the all-systems and structural test stage, and the first two flight stages were being assembled. The contractor was furnishing parts and components. The contractor will build the dynamic test stage, the facility checkout stage, and all subsequent flight stages at the Michoud Plant.

Assembly of a full scale S–IC mockup was completed in June at the Michoud Plant. This mockup will be used to establish wiring runs and tubing layouts, and to check out interface points. (Fig. 1–12).

The S–II stages were under design and development. Fabrication of the battleship test structure was completed and tanking tests were scheduled to begin soon. The S–II structural, all-systems, dynamic and facility checkout test stages were all in various stages of fabrication and checkout.

The S–IVB stage of Saturn V, substantially similar to the S–IVB stage of the Saturn IB, was being designed and developed. Late in

May NASA announced that it would negotiate with a private contractor for a $5 million S–IVB stage electro-mechanical mockup to be used with a Saturn V launch vehicle simulator at the Marshall Space Flight Center. The mockup would be used in the study of prelaunch, launch, and orbital checkout of the third stage.

The 1.5-million-pound-thrust F–1 engine, in a cluster of five, will power the first stage (S–IC) of the Saturn V vehicle. During this reporting period, the Flight Rating Test (FRT) engine configuration was released. Preliminary flight rating test demonstrations had been successfully completed on six of the nine components requiring them. Effort continued to obtain an injector which would provide maximum stability with increased performance. Tests indicated that the two injectors being considered for the FRT engine were meeting the minimum specific impulse requirements, while exhibiting excellent stability characteristics.

The second and third production engines were acceptance tested and shipped to Marshall Space Flight Center for static tests. The first two of three F–1 production acceptance test stands were completed at Edwards Air Force Base and turned over to the engine contractor.

The 200,000-pound-thrust J–2 engine—used in the S–IVB stage in Saturn IB and Saturn V and in the S–II stage of the Saturn V—progressed in development to the point that it was ready for its Preliminary Flight Rating Test (PFRT); several 500-second full-duration tests had been completed. (See fig. 1–13.) Major subsystems had demonstrated the performance required for these tests, and the PFRT will assure that the engine system is suitable for ground tests and unmanned flight. The contractor delivered the first production engines to the S–IVB stage contractors for use in ground tests of the battleship stages. A number of other J–2 engines were either in final assembly or ready for shipment.

By a major program decision made during the reporting period, the Saturn V will be uprated to increase its payload capability from 90,000 to 95,000 pounds. The uprating will be accomplished by increasing engine thrust, propellant capacity, and by making other improvements.

Automatic Checkout

In the Apollo program, computer-controlled Automatic Checkout Equipment (ACE) is used to check out spacecraft modules, launch vehicle stages, and integrated space vehicles. The ACE stations use general purpose digital computers as central processors and present the data on display devices for review and action by technical personnel. The ACE program is planned as an orderly, step-by-step process consistent with the extremely high reliability goals of the Apollo program.

Approximately 50 Apollo ACE stations in 7 States will be located at factories, test sites, and the launch site to test the spacecraft modules and launch vehicle stages as they flow to Cape Kennedy for integration and launch. As of January 1, 1964, the following six stations had been installed:

Location	*Intended use*
Huntsville, Ala	Check out S–I Stage (Saturn I)
Michoud Plant, La	Check out S–I Stage (Saturn I)
Huntsville, Ala	Check out Instrument Unit (Saturn I)
Huntsville, Ala	Development Facility for Saturn I Launch Vehicle Check out Equipment
Cape Kennedy, Fla	Check out and Launch of Saturn I Vehicles
Cape Kennedy, Fla	Development Facility for Apollo Spacecraft Check out

During this reporting period, two more were installed:

Location	*Intended use*
Huntington Beach, Calif	Development Facility for S–IVB Check out.
Downey, Calif	Command and Service Module Check out of Apollo Spacecraft.

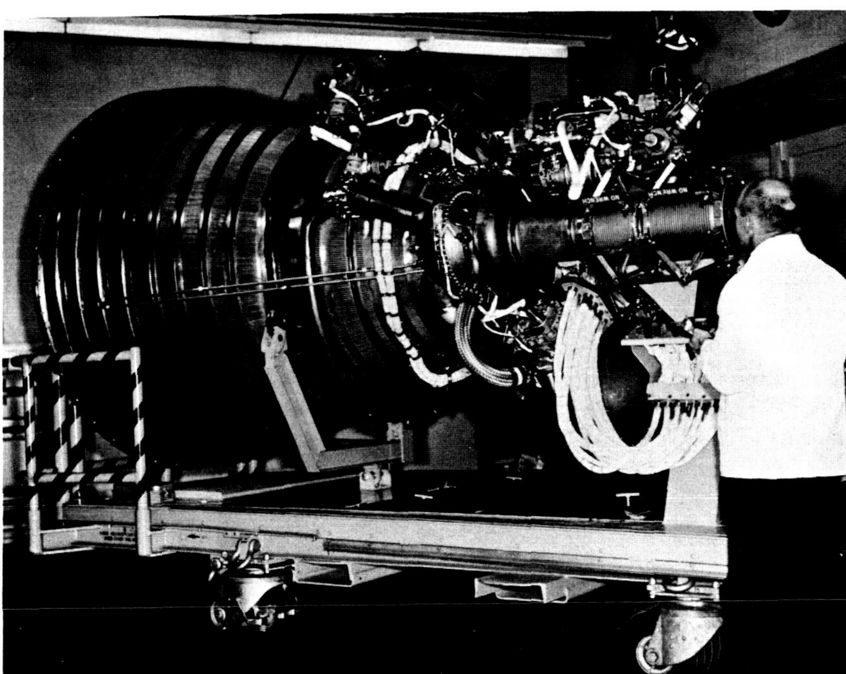

Figure 1–13. The J–2 engine, to be used in the S–II and S–IVB stages.

Space Medicine

The Apollo space medicine program activities were concentrated on space suits and the portable life support system, bioinstrumentation, testing of environmental control system and atmospheric instrumentation, experimental studies, and related areas.

The space suit for Saturn IB earth-orbital missions was delivered to the Manned Spacecraft Center for evaluation. The Gemini space suit was evaluated and found satisfactory for Apollo earth orbital flights. Development continued also on a space suit adequate for Apollo crew tasks during the lunar missions. As a potential alternate, an aluminum pressure suit was being evaluated at the Manned Spacecraft Center; it was called a "constant volume, rigid articulated, anthropomorphic protective suit." The center also evaluated a prototype gas-operated portable life support system and began development of a liquid portable life support system.

Work was also begun on the operational support test for environmental control systems. In atmospheric instrumentation, a carbon dioxide detector and a gas chromatograph was developed. A contract was awarded for development of a flight gas chromatograph.

Control baseline medical studies for Apollo were selected. Water balance tests were nearing completion and metabolic studies were initiated. Experimental studies to determine random and angular vibration tolerances were progressing.

Astronaut Training

Major emphasis was being placed on the scientific training as the astronauts continued their general and Gemini training and as they intensified their Apollo training. To enable the astronauts to choose lunar landing sites, make necessary observations, and map the moon, they were actively studying geology and other sciences—both in the classroom and on field trips.

The geological training was conducted by three geologists assigned to the Manned Spacecraft Center and four geologists loaned by the U.S. Geological Survey. The first of four 48-hour courses began in February; it was comparable to a college introductory course, differing only in its heavy stress on lunar geology. The first part emphasized mineralogy and petrology, and the second will deal with basic principles, including the stratification of rocks.

During the reporting period, the astronauts studied geological phenomena in the Grand Canyon, at Marathon Basin and Big Bend National Park in west Texas, and at Meteor Crater and Sunset Crater near Flagstaff, Ariz. They made telescopic observations of geological aspects of the moon from the Kitts Peak National Observatory near Tucson, Ariz.

In other training for Apollo, the astronauts participated in design of the Apollo Systems Trainers. One week of briefing on the Apollo systems was conducted for the fourteen new astronauts. Five astronauts participated in evaluating the command module, displays, controls, and pressure suits in a mockup installed on the centrifuge at the Naval Air Development Center, Johnsville, Pa. They began an engineering evaluation on the X–14 vertical takeoff and landing aircraft for potential use in engineering and training activities.

They also continued monitoring design of the free flight lunar landing research vehicle, which was essentially completed and nearing readiness for flight tests. Astronauts participated in several engineering simulations at the Manned Spacecraft Center and various contractor plants.

Fifteen astronauts completed helicopter checkout, receiving an introduction to vertical and hover flight such as will be required in the lunar excursion module.

Scientist-Astronaut Program Planned

NASA established, in May 1964, a plan to recruit scientist-astronauts in an effort to obtain maximum scientific return from lunar exploration. The National Academy of Sciences working with NASA's Office of Space Science and Applications was to define scientific qualifications and the Manned Spacecraft Center, other qualifications. NASA planned to announce selection criteria and solicit applications from qualified persons in the fall of 1964.

At the outset, Apollo crews will be selected from the present 29 astronauts, all of whom have experience as test pilots in high-performance jet aircraft and some of whom will have developed proficiency in the earlier Gemini flights. The scientist-astronauts are to be included in the flight crews on the later lunar flights. Since the spacecraft crew will be called on to perform rather difficult flying tasks, it will be necessary to give the scientist-astronauts special flight training.

Scientific Experiments

As the Gemini scientific effort moved closer to implementation, increased attention was given to planning for Apollo scientific experiments. Micrometeoroid detection satellites, developed by NASA's Office of Advanced Research and Technology, were scheduled for the last three Saturn flights (SA–8, SA–9, and SA–10). These satellites would record the frequency of meteoroid strikes.

Experiments for Apollo earth-orbital and lunar missions were in the planning stages. A major symposium for scientists concerned with Apollo experiments was held in June at the Manned Spacecraft Center. The major purpose was to acquaint the scientists with current Apollo planning and the constraints which would apply to the execution of experiments on the various launches.

Ten committees of leading scientists were formed and began considering experiments in field geology, geochemistry, magnetic measurements, bioscience, active seismology, passive seismology, mineralogy and petrology, heat measurements, gravity measurements, and atmospheric measurement. Ideas for experiments in these fields were to be solicited from scientists throughout the Nation.

As in the Gemini experiment program, NASA's Office of Space Science and Applications requested that domestic and foreign scientists submit proposals for scientific experiments for Apollo flights. For the Apollo program, the earliest flights which could accommodate such experiments would be the fourth and fifth earth-orbital missions employing the Saturn IB launch vehicle and the first lunar mission employing the Saturn V launch vehicle.

Supporting Resources

To provide for the Gemini and Apollo projects and further augment the Government-industry base for future space activities, the Agency continued its planned buildup of facilities and supporting resources. Construction of new facilities went forward, and progress was made in providing additional propellant supply sources for both east and west coast requirements.

Construction of Facilities

Facilities resources are grouped into four principal categories: Institutional, design and manufacturing, development and acceptance testing, and operations.

Institutional.—Marshall Space Flight Center at Huntsville, Ala., is the largest of the Manned Space Flight institutional facilities. Marshall, long known for development, manufacture, and testing of launch vehicles, is now concentrating on management of industrial firms producing and testing large boosters, engines, and components.

During the January–June 1964 period, construction of Marshall's new Engineering and Administration Building and the Engineering Building in the test laboratory area was completed. In addition, the road to the Saturn V loading dock and the Subassembly Acceptance Building were nearing completion.

At the Manned Spacecraft Center in Clear Lake, Tex., southeast of downtown Houston, the institutional resources were close to completion by early 1964. (See fig. 1–14.) In 2 brief years, the Manned Spacecraft Center has become a functional, well-equipped site for NASA's management of manned spacecraft projects and for actual development and ground-testing of spacecraft systems, both at the Center and at White Sands Missile Range. The facilities resources at the Manned Spacecraft Center directly support the Gemini and Apollo Programs and represent a long-term investment for future NASA programs.

During the spring of 1964 NASA occupied twelve facilities, including the Project Management Building, Flight Crew Operations Facility, Spacecraft Research Building, and Technical Services Shops. The major moves from Ellington Air Force Base and leased facilities were accomplished from November 1963 through March 1964. At the end of the period, twenty facilities were occupied at the Clear Lake site and construction of several others was progressing on schedule. The remaining leases for administrative space in Houston were terminated in June.

Construction contracts awarded during the first half of 1964 included those for the Vibration Test Laboratory, to be used to test the complete Apollo spacecraft under conditions that simulate vibrations encountered during launch and in flight; the Mission Simulator Facility, to house simulators for astronaut training; and the Spacecraft Central Technology Facility, to be used to test spacecraft navigation and guidance systems.

The John F. Kennedy Space Center, Cocoa Beach, Fla., is the site of all NASA's manned launches. Acquisition of the 87,400-acre Merritt Island Launch Area (part of the Center) was essentially completed by June 30. The major institutional facilities completed during the first half of 1964 included: The Orsino-Banana River Road and Causeway, the Merritt Island Industrial Area utility and road systems, the Central Supply Building, the Cable Storage Facility, the Central Telemetry Facility, the Dispensary, the Plant Maintenance Facility, and the Merritt Island Railroad. In addition, construction was started on the following projects: The John F. Kennedy Space Center Headquarters, the Central Instrumentation Facility, the Base Operations Building, the Security Facilities, conversion of Merritt Island Road to a dual-lane highway, the barge lock and channel at Canaveral Harbor, and expanding the road and utility networks.

Design and Manufacturing.—The Michoud Plant near New Orleans, La., is a Government-owned, contractor-operated facility under the management of the Marshall Space Flight Center. Booster stages for the three Saturn-class launch vehicles are manufactured at Michoud.

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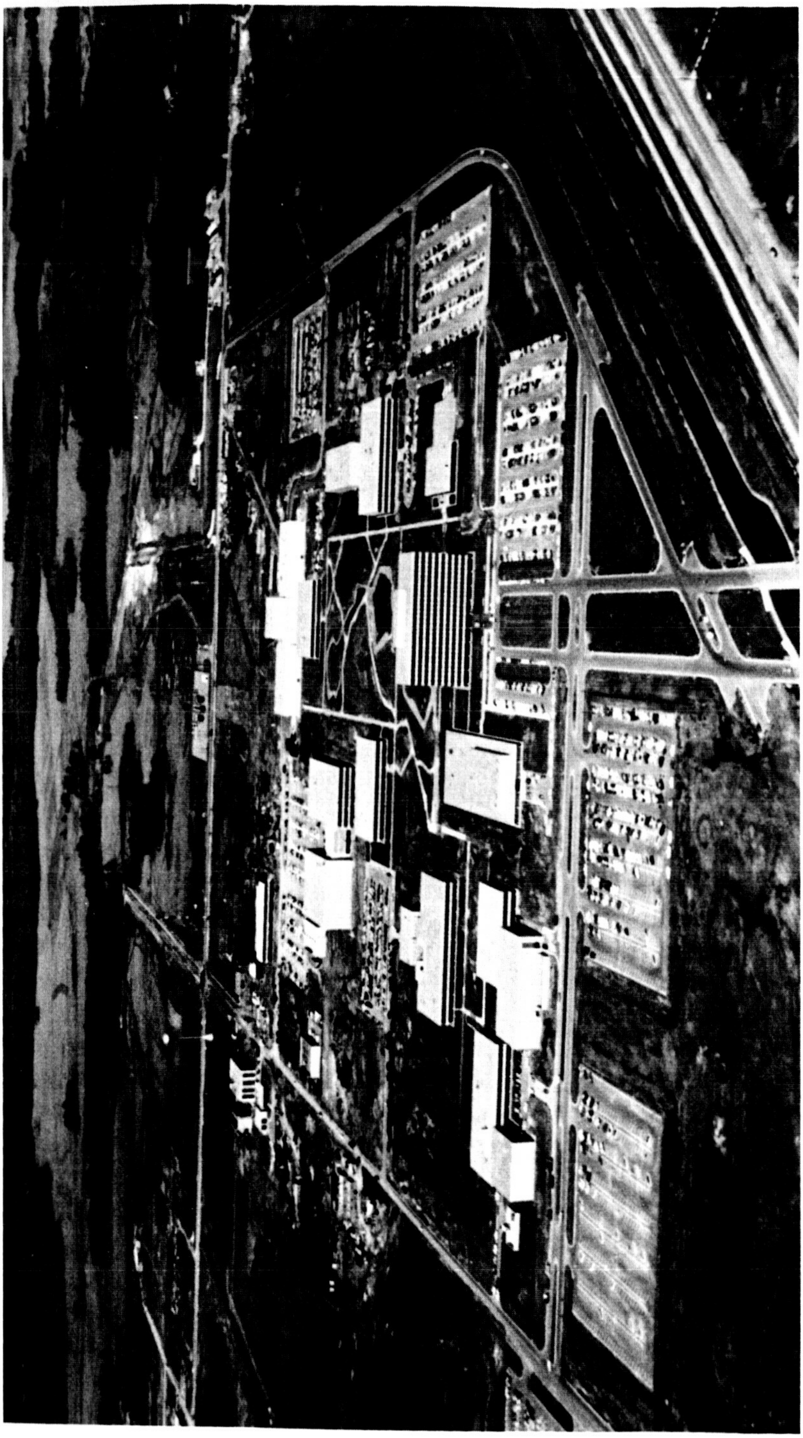

Figure 1–14. Aerial view Site 1, Manned Spacecraft Center, Houston, Tex.

All major facility modifications required to manufacture the S–IB stage, the booster stage for the Saturn IB, have been completed and production of flight stages was started.

Construction of the High-bay Vertical Assembly and Hydrostatic Test Buildings and the High-pressure Test Facility for the booster stage of the Saturn I was completed. All remaining support facilities, including the final S–IC checkout building, were progressing on schedule, and the new Engineering Building to house Michoud's technical and administrative personnel was nearing completion.

At Seal Beach, Calif., another Government-owned, contractor-operated facility under construction since late 1962 is to produce the S–II, the second stage of the Saturn V. Facilities completed during the first half of calendar year 1964 include the Verical Assembly and Hydrostatic Test Facility, the Structural Static Test Facility, the Pneumatic and Packaging Plant, and the Loading Dock. Figure 1–15 shows the S–II bulkhead and skirt assembly.

At the contractor-owned facility at Huntington Beach, Calif., installation of the returnable, special Government test equipment was completed and S–IVB stages were being manufactured. At Air Force Plant 16, a Government-owned contractor-operated facility at Downey, Calif., design of a third LEM Test Position began during

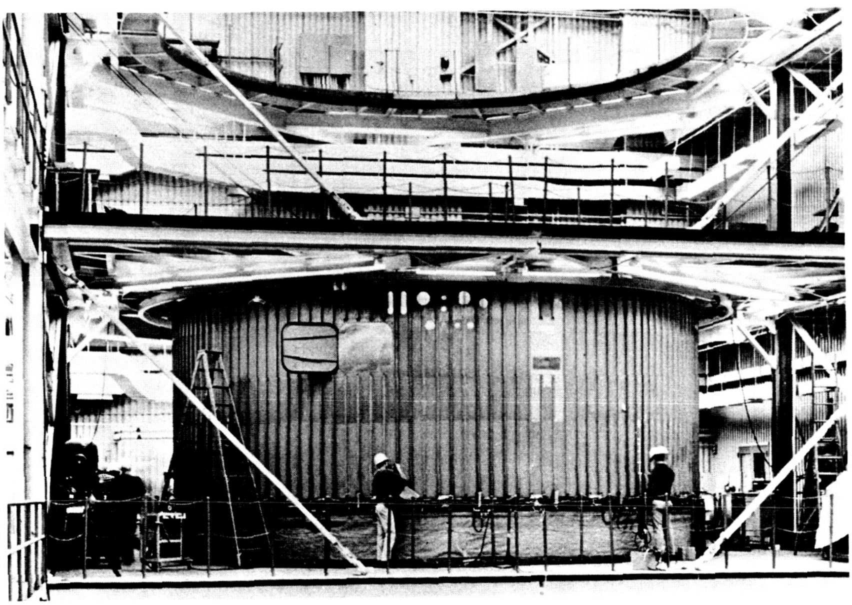

Figure 1–15. S–II bulkhead and skirt assembly, Seal Beach, Calif.

this period and production of Apollo spacecraft and S–II stage components continued.

Development and Acceptance Testing.—These facility resources provide for testing of hardware during the developmental phases of the program and for acceptance testing of production equipment. Much developmental testing of launch vehicle stages, engines, and components in support of the Saturn I, Saturn IB, and Saturn V projects is done at the Marshall Space Flight Center. Facilities for static, dynamic, cold flow, and components testing of Saturn I and IB stages and the H–1 engine already exist at the Center.

Marshall's Saturn V test facilities (S–IC Stage and F–1 Engine Static Test Stands and F–1 Turbopump Components Test Facility) were close to completion. During this reporting period the S–IC static test stand, including deflector, high-pressure water system, and adaption hardware, was completed. Also finished were the observation bunker, the preparation building and high-pressure water system for the F–1 Engine Static Test Stand, the F–1 turbopump test stand for the Component Test Facility, and the Hydraulic Test Facility. Construction of the extension to the test operations support facilities for the Saturn V continued as planned. Figure 1–16 shows the Saturn I and Saturn V Dynamic Test Stands.

Construction of the Saturn V Ground Support Equipment Test Facility, initiated in 1963, was also on schedule. Construction began on the Barge Dock and Loading Facility, to be used for loading launch vehicle stages on barges en route to John F. Kennedy Space Center and Mississippi Test Facility.

The Environmental Test Laboratory, under construction at the Manned Spacecraft Center, will contain two of the world's largest man-rated environmental chambers. It is to be used to test assembled spacecraft modules and systems, and to train astronauts in simulated space and lunar operations.

Construction of a new static test stand complex at Edwards Air Force Base, Calif., was started in March 1962. During the first half of 1964, construction of the three F–1 engine test stands (1–C, 1–D, and 1–E) was completed, and acceptance testing of F–1 engines began on Test Stand 1–D. Also, installation of an environmental capability on Stand 1–E was started, and facility checkout of the Control Center was completed.

At the White Sands Missile Range in New Mexico, construction of the Apollo Spacecraft Propulsion Systems Development Facility for the command and service modules was completed. Construction began on facilities in support of developmental testing of the LEM propulsion systems. These facilities will include three test stands with altitude simulation capability.

At the Sacramento Test Site, facility checkout of Test Stand Beta 1 was completed. Construction of Test Stand Beta 3, initiated in April 1963, and the Propellant Gas Storage and Transfer System, started in March 1963, was completed.

Construction of the S–II Test Stands (Coca I and Coca IV) at Santa Susana, Calif., was completed and facility checkout was started.

When completed, the Saturn V Test Complex at the Mississippi Test Facility (MTF) will include a dual-position S–IC test stand, two single-position S–II stands, and a data acquisition facility. The in-

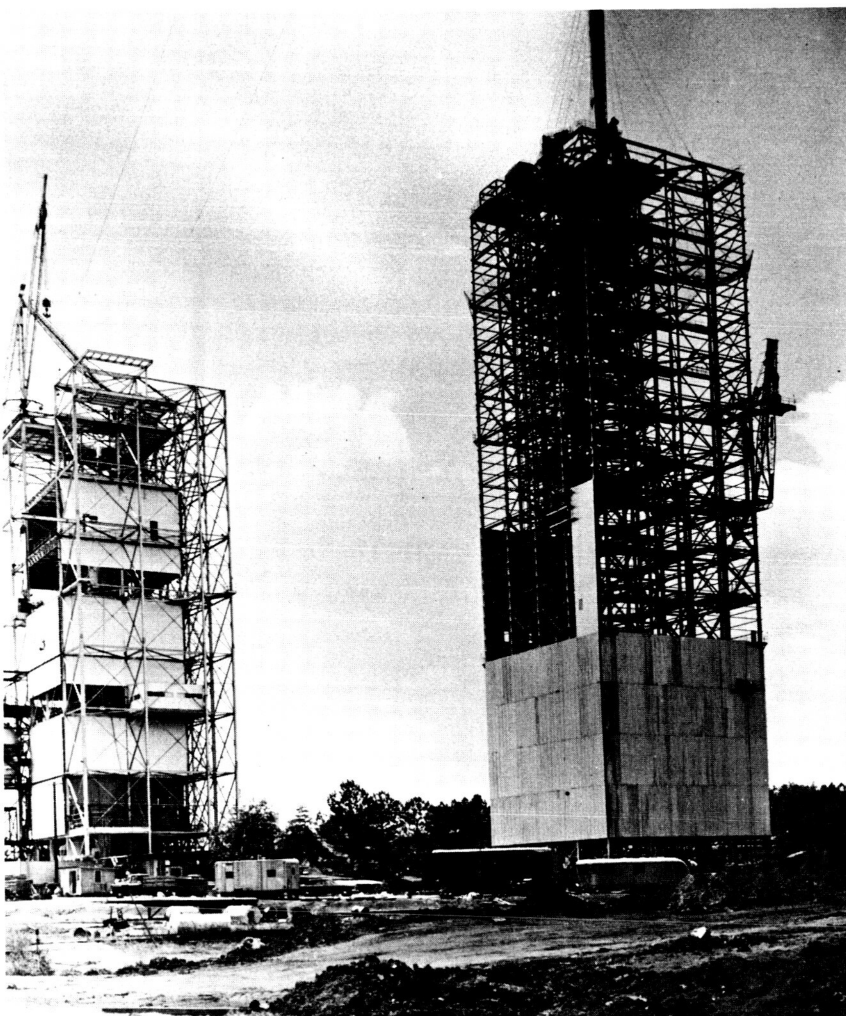

Figure 1–16. MSFC Saturn I and V Dynamic Test Stands.

dustrial and engineering complexes, located in the 13,500-acre main test area, will include an office and engineering building, a data-handling facility, a component service facility, an electronics and materials laboratory, warehousing, and supporting facilities.

At MTF, ten construction and procurement contracts were completed. Forty major construction, procurement, and technical system contracts were underway. The major construction areas included the first S–IC test position, the first S–II test stand and the foundation for the second, roads and railroads, a navigation lock, and major support facilities. (See fig. 1–17.) Construction also began on the canal system, the lock, the Laboratory and Engineering Building, the warehouse, the Site Maintenance Building, the Emergency Services Building, electrical distribution systems, and other supporting facilities.

The manned spacecraft facilities, where manned spacecraft undergo final testing prior to assembly and launch, are located in the Merritt Island Launch Area (MILA) at the John F. Kennedy Space Center.

Facilities completed at MILA during this reporting period included a Parachute and Paraglider Building, a Weight and Balance Building, a Fluid Test Complex, and a Static Test Fcility. Construction of the first phase of the Operations and Checkout Building, initiated in February 1963, was about 95 percent complete by the end of June 1964.

Operational.—At the John F. Kennedy Space Center, additional modifications to Launch Complex 19 for the Gemini Launch Vehicle were accomplished. Modifications to the former Mercury pad (No. 14) continued to meet the launch schedule for the Atlas-Agena Gemini Target Vehicle.

Redesign of Launch Complex 34 was started. Complex 34, which has been used for Saturn I shots, is to be modified to launch Saturn IB; actual work is to begin after the eighth Saturn I launch.

All Saturn V launches are to be from Complex 39. The steel frame for the low-bay area of the Vertical Assembly Building was erected and the steel frame for the high-bay area, which will be about 525 feet high, was approximately 50 percent complete. Related support buildings were well underway and 340 feet of steel superstructure for the first Launch Umbilical Tower (LUT) were erected during the first half of 1964. (See fig. 1–18.) In addition, construction contracts were let for the first launch pad, its propellant systems, and the road (crawlerway) connecting the Vertical Assembly Building with the pad. Also placed under contract were dredging operations for the second launch pad and crawlerway and utility systems for Complex 39. (See fig. 1–19.)

Figure 1–17. The S–II Test Stand–A–2, Mississippi Test Facility.

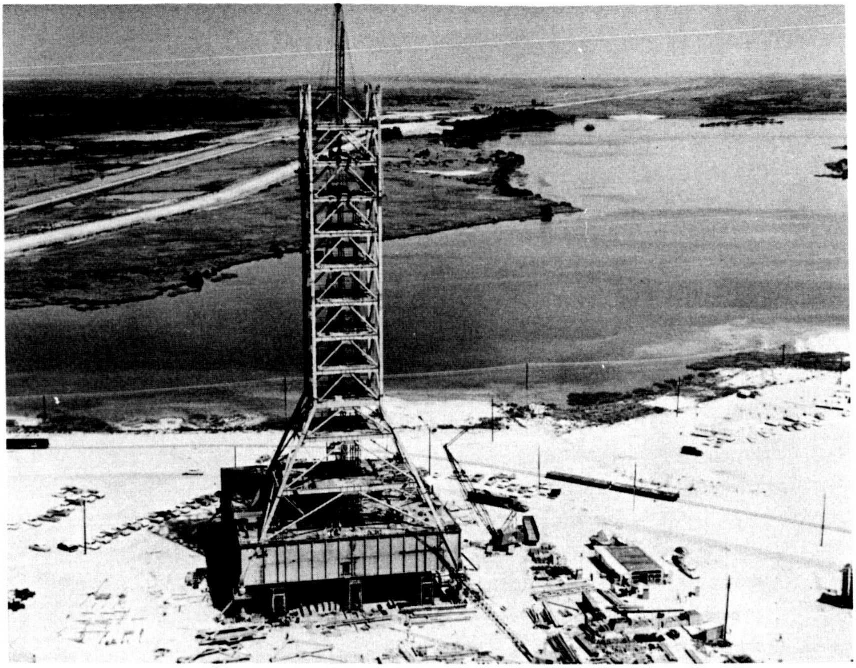

Figure 1–18. Launch Umbilical Tower 1, Merritt Island Launch Area

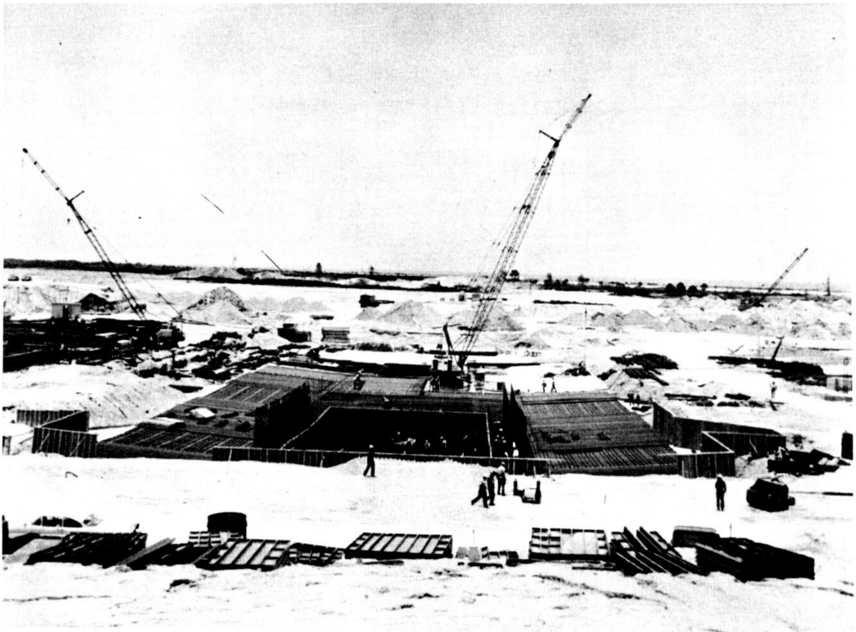

Figure 1–19. Launch Pad 39A, MILA.

Propellant Support

Liquid hydrogen support capability was increased significantly during the first half of 1964, when a 60-ton-per-day, commercially owned facility, the largest increment yet, became operational in the Sacramento, Calif., area. This plant, erected primarily to support NASA west coast programs, will produce the cheapest hydrogen yet on the west coast when operated at maximum load.

Under a contract award made during the period, the contractor will provide from his own plant near New Orleans a 30-ton-per-day liquid hydrogen supply to support test activities on the east coast, particularly the Mississippi Test Facility and the Marshall Space Flight Center. The plant, to become operational in July 1965, will also have large liquid hydrogen and liquid oxygen storage facilities.

Action was initiated to provide an additional 2,500-ton liquid oxygen storage facility at Edwards Air Force Base to support the F–1 engine test activities. This additional inventory will significantly assist in keeping pace with increasing requirements, will support peak requirements arising at irregular intervals, and will permit uninterrupted test activity.

Significant increases in liquid oxygen and liquid nitrogen capacity were being planned for the east coast. Two firms announced plans for 1,000-ton-per-day air separation plants in the New Orleans area, and two others planned to construct 1,000- and 400-ton-per-day plants in the Cape Kennedy, Fla., area.

An award was made for a new monomethyl hydrazine (MMH) supply source to support the Gemini, Apollo, and Surveyor programs. This award resulted in an industry-owned plant at Lake Charles, La., which went into operation in April 1964.

Advanced Manned Missions Program

The Gemini and Apollo projects presently require by far the major part of the national resources allocated for manned space flight. Beyond these projects, it is the function of the Advanced Manned Missions Program to investigate and define the more promising alternatives which are available for further progress. In this endeavor, the technological, industrial and operational bases of the Gemini, Apollo, and Saturn programs represent essential building blocks.

At any given time the systems under the cognizance of Manned Space Flight can be divided into four groups: Approved projects, alternative and growth concepts which might be conducted within the scope of approved projects, concepts for the extension of approved projects, and future concepts requiring major new development effort.

The last three groups are under the cognizance of the Advanced Manned Missions Program office.

The potential missions and systems for future manned space flight lie in three basic mission areas: Earth orbital, lunar, and planetary. A fourth area, launch vehicle systems, constitutes an underlying base for all missions. These four areas comprise the major divisions of advanced study effort within the Advanced Manned Missions Program office.

The earth orbital programs of the United States have been and will continue to be the foundation for exploring space. The specific goal of the NASA study effort in manned earth orbital missions is to determine the best methods for advancing space exploration and exploitation through basic and applied research in the space sciences and engineering experimentation in earth orbit and for providing a national capability for manned flight in earth orbit. In this connection, the three basic groups of experimental programs that were under study during this period are biomedical research, space science research, and engineering research and development. (See chap. 2 for further discussion of this subject.)

In the biomedical area, the focal points of study are weightlessness, long confinement, potential environmental hazards, and the effects of these factors on man's performance and physiological capability. Typical areas in scientific research include astronomy, biology, geophysics, meteorology, and radiation phenomena. Engineering research and development activities include studies of orbital launch facilities, crew systems, extravehicular operations, propulsion, communication systems, and structures and materials research.

All three areas will depend on the development of an operational, multi-man Orbital Research Laboratory with a flight duration of as long as several years. NASA was studying three promising approaches to this Orbital Research Laboratory: A system based on the Apollo spacecraft; an Orbital Research Laboratory capable of supporting four to eight men; a large laboratory with up to 24 men (possibly made up of modules from the smaller laboratory). Logistics problems and the employment of ferry vehicles based on Gemini and Apollo were also being studied.

Advanced studies in the lunar area were concentrating on missions and systems which could be used to conduct a significant scientific exploration program on the lunar surface and prepare the way for whatever level of lunar flight activity may prove desirable as a result of the early Apollo landings. It is anticipated that early exploratory activities will lead to extensive exploration followed by an exploitation phase. Early extensions of Apollo capability may be obtained by attaching "saddlebags" to the existing spacecraft (Lunar Excursion

Module—LEM) in the event payload margins can be made available.

Other methods of providing longer lunar exploration periods and a roving capability depend on the development of a logistics carrier, such as an unmanned LEM-descent stage or by means of cryogenic landing stages. Manned lunar orbital survey flights with high resolution photomapping and other remote sensors are expected to prove valuable in the exploration phase. All of these possibilities were being studied and systematically analyzed during the period.

The prime task of the lunar study program in the immediate future is to define the alternative approaches to lunar exploration in sufficient detail to permit a sound choice among them. A second task is to develop a base of knowledge which will ensure efficient and expeditious development of the selected exploration system. To accomplish these tasks, the following possibilities were being studied:

(a) Apollo staytime (period astronauts can remain on lunar surface) extension in which additional payload capacity would be developed in the Apollo system; this payload would be used to transport packages of surface exploration equipment attached to the outside of the LEM.

(b) Longer staytime missions in which two Apollo shots are required for each mission. One of these would transport two astronauts via a 14-day lifetime LEM; the other would deliver surface exploration equipment and supplies to the lunar surface via an unmanned LEM-descent stage.

(c) Missions in which two or three direct-flight Saturn V shots are required for each mission—one to deliver material to the lunar surface, one to transport three astronauts to the moon, and possibly a third to pick up the astronauts 90 days (or more) later and return them to earth.

Expeditions to the planets of our solar system are the ultimate goal of manned space flight in this century. Study efforts in manned planetary exploration were concentrating on defining the objectives of planetary exploration as well as the means, methods, and resources required to accomplish such exploration. Both detailed and broad conceptual studies were being performed.

The broad conceptual studies will aid in defining an overall program, provide direction to advanced technology programs, and delineate information required from the unmanned interplanetary programs (e.g., Mariner flyby and Voyager lander). The more detailed studies are to assure mission feasibility; determine the utility of existing or planned hardware; and define the technological, economic, and schedule aspects of manned planetary exploration.

The study effort that was underway consists of an evaluation of several alternate mission profiles and methods of mission accomplishment.

Also, studies were being conducted to determine whether hardware currently being developed for other NASA space flight programs could be used for these missions.

Future manned missions depend, of course, on launch vehicle systems for a successful earth launch phase. The presently approved launch vehicle program provides an increasing payload capability over the next 5-year period, culminating in the Saturn V. Further improvements in payload capability may be obtained by uprating these launch vehicles or by developing new and larger vehicles. Another promising possibility for providing more efficient transfer of men and materials to earth orbit is a reusable launch vehicle system.

Studies were being made of the potential increases in capabilities of the launch vehicles already under development. Since many of the possible future missions could be accomplished by improved or uprated Saturns, these studies were concentrating on the growth potential of these vehicles.

In another study area the efforts were being aimed at defining the next large launch vehicle after Saturn V. This one should be developed to provide the very large weight-lifting capability required for such missions as large space stations, large lunar base operations, and manned planetary exploration. This effort is designated "Post Saturn."

A third and very promising area that was being studied is that of reusable orbital transport vehicles. The cost effectiveness advantages at the anticipated levels of manned activities in earth orbit from the middle 1970's and into the 1980's as well as the need to provide for the earth-to-orbit travel of nonastronaut passengers places a premium on this approach.

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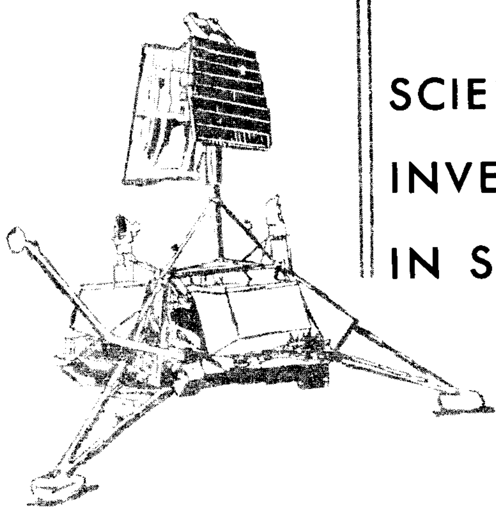

SCIENTIFIC INVESTIGATIONS IN SPACE

The report period witnessed a very important development in space science as scientific investigators broadened their interest from a concentration on the results of a single satellite to studies of data supplied by all spacecraft. Pieced together this information began to provide them with a clearer picture of the space about the earth as a whole.

Scientists tackled such problems as the nature, behavior, and irregularities of the upper atmosphere, including the ionosphere, and its dependence on solar radiation. They also sought to find the sources of energy (such as electrons), which cause the mysterious atmospheric airglow and determine the chemical compounds which emit the light in the aurorae. Others investigated the radiation in the Van Allen region and measured the earth's magnetic field. In addition, life scientists selected experiments to be carried aboard the first biosatellites planned to be orbited in about 2 years.

Geophysics and Astronomy

Geophysical Satellites

On March 27, the second Ariel international geophysical satellite was launched. Ariel II, like the first Ariel launched by NASA for the British from Cape Kennedy on April 26, 1962, carries experiments prepared by scientists from the United Kingdom. The satellite collects and transmits data on radio frequency radiation from space, on the vertical distribution of ozone in the atmosphere, and on micrometeoroids found in the spacecraft's path in regions near the earth. It achieved a perigee of 180 miles, an apogee of 843 miles, and is inclined 52° with the equator.

The report period saw an increasing interest in stellar bodies emitting these radio frequency radiations observed by Ariel II which led to initial plans for a radio astronomy satellite to study this type of radiation. Also during this time, Alouette, the Canadian topside sounder satellite orbited by NASA in September 1962, supplied data on the nature, behavior, and irregularities of the upper ionosphere, and its dependence on solar radiation.

On April 14, 1964, at Cape Kennedy, as the Orbiting Solar Observatory B spacecraft was being mated to the upper stage of its Delta launch vehicle, the rocket motor ignited, injuring 11 men—3 fatally. The accident also damaged the facility and wrecked the spacecraft. A thorough investigation was underway to determine the cause of the accident and to prevent similar ones.

First results reported by the orbiting Explorer XVIII (launched on November 26, 1963) have provided the most accurate measurements of the strength and direction of the interplanetary magnetic field yet available to investigating scientists. In addition, this geophysical satellite revealed the existence of a shock front on the sunlit side of the earth produced by the supersonic flow of the solar wind past the earth's magnetosphere. (The magnetosphere is a region of space extending from the surface of the earth to the outer edge of its magnetic field.) Explorer XVIII is in a highly eccentric orbit ranging from 119 miles to a height of 122,800 miles.

Also in this period, the 17th Explorer supplied further information on the physical and chemical processes taking place in the upper atmosphere. The spacecraft—launched in April 1963—revealed that atmospheric density varied markedly, from day to day, at a given latitude for the same time of night or day. Such variations occurred even when the sun appeared to be quiet and no magnetic disturbances were evident by scientific observers. Explorer XVII also indicated the presence of a source of heating in the nocturnal ionosphere.

Sounding Rockets and Balloons

During the first 6 months of 1964, 47 sounding rockets were successfully launched over a wide area of the earth to study the density and temperature of the atmosphere at altitudes ranging from 60 through 100 miles. Six of these carried instruments designed to measure atmospheric temperature, pressure, and composition. Four others, launched in India near the equator, searched for the electrical current (electrojet) which appears to circulate around the globe producing some of the fluctuations observed in earth's magnetic field. Still other rockets helped scientists understand the cause of the whitish-green night airglow in the atmosphere described by Astronauts Glenn, Carpenter, and Cooper (*10th Semiannual Report*) and the more spectacular glow of the northern lights.

The use of instrumented balloons in astronomy and in studies of cosmic rays continued to increase substantially. For example, on March 5, a balloon in a flight over Texas carried a coronograph to a height of 90,000 feet to observe the corona surrounding the sun. An instrument of this type will be flown on the Advanced Orbiting Solar Observatory planned for launching near the end of the decade.

Lunar and Planetary Programs

During the period, another in the Ranger series was launched; two Mariner spacecraft were being readied for fly-bys of Mars; and a contract was signed for the design of a lunar orbiter satellite.

Ranger

Ranger VI was successfully launched from the Atlantic Missile Range on January 30, and landed on the moon on February 2, only 20 miles from its aiming point. Although the flight appeared to be normal, a failure of undetermined cause prevented the spacecraft's six TV cameras from transmitting any pictures of the lunar surface during the last 17 minutes of flight before impact (*10th Semiannual Report*, ch. 2). Investigators are reasonably certain that a premature turn-on of the television subsystem during the launch phase of the mission caused this failure.

Modifications incorporated into the television subsystem of Ranger B (Ranger VII)—scheduled for launching during the third quarter of 1964—are to minimize the possibility of future premature TV turn-on. During this report period, Ranger B underwent extensive testing to determine the effectiveness of these changes. Like Ranger VI, this spacecraft was planned to take TV pictures of the moon's surface vital to the Nation's scientific and manned lunar programs. Its 6 high-quality cameras should take over 4,000 pictures during the final 17 minutes of flight—the last of these at least 10 times better than any available from earth-based photography and possibly good enough to identify objects as small as a compact automobile. (After the close of this report period, on July 31, this seventh Ranger furnished thousands of lunar photographs. Details will be published in the *12th Semiannual Report.*)

Mariner and Pioneer

During the first 6 months of 1964, most of the key tests of Mariner were completed and a proof test model was built. Two flight spacecraft were assembled and systems testing began. Two Mariners are to be launched by Atlas-Agena boosters during the last quarter of 1964 for fly-bys of Mars in mid-1965. (Figs. 2–1 and 2–2.)

Design review of the Pioneer spacecraft and experiments for its first two flights were completed and fabrication of the prototype was underway. In addition, proposals for experiments for flights three and four were received and were being evaluated.

Surveyor

The Surveyor program is developing more highly sophisticated spacecraft than Mariner or Ranger which can make soft landings on the moon, advance scientific knowledge by conducting experiments there, and provide engineering and mapping data in support of future manned lunar landings.

During the report period Surveyor's subsystems underwent rigorous testing to reveal weaknesses in the spacecraft's design and make it possible to correct them before flight testing. Early recognition and solution of technical problems before assembly and flight tests of the spacecraft resulted in significant progress.

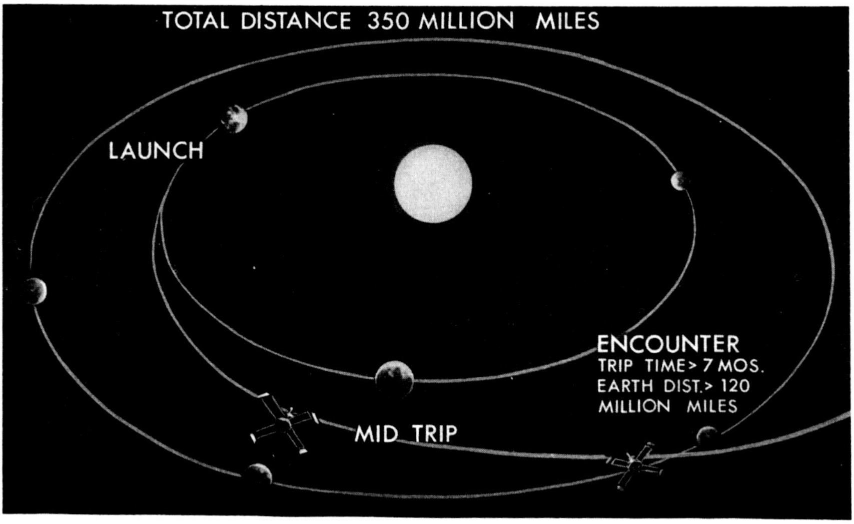

Figure 2–1. Typical Mariner-Mars trajectory.

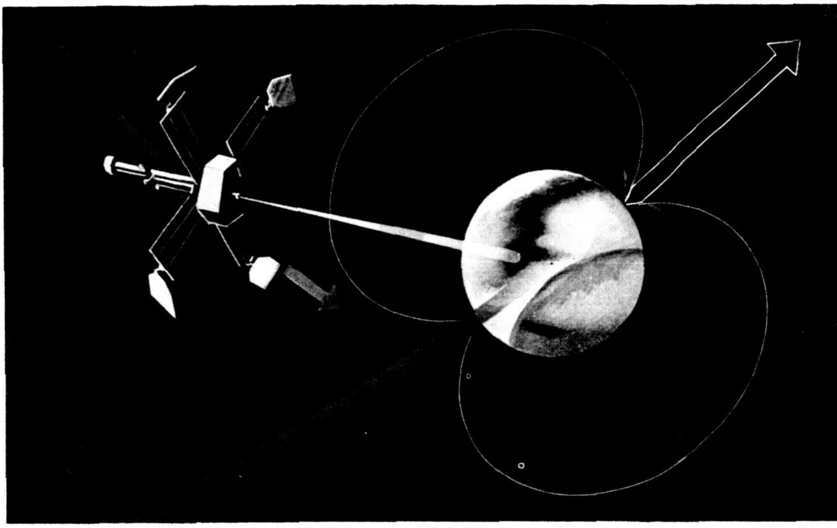

Figure 2–2. Mars encounter of Mariner spacecraft.

Surveyor also passed a number of major milestones. Among these were nine consecutive successful tests of the main retrorocket which confirmed its suitability; drop tests which determined that the landing gear shock absorbers were completed satisfactory; and the fabrication, testing, and delivery of dynamic models of the spacecraft to be used in Centaur development flight tests. In addition, substantial progress was made in developing instruments for operational Surveyor missions.

Following extensive ground testing, four engineering test flights will be conducted to evaluate the performance of the spacecraft and its systems during launch, transit, and landing phases. Next will come scientific studies of the moon through instrumented landings and the determination of suitable landing sites for astronauts.

Studies continued on the feasibility of small lunar-surface roving vehicles to be carried aboard more advanced Surveyors for conducting area surveys and exploring features of special interest. (Fig. 2–3, p. 68.)

Lunar Orbiter

In May, NASA signed a contract for the development of Lunar Orbiter, which will be this country's first satellite of the moon. The design was scheduled for completion before the end of 1964. The satellite's cameras will take high-resolution photographs of considerable areas of lunar surface and help select landing sites for unmanned and manned spacecraft. As a secondary objective Lunar Orbiter will

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examine the moon's gravity field and space environment over an extended period of time. Five missions were authorized for the satellite—the first scheduled for mid-1966.

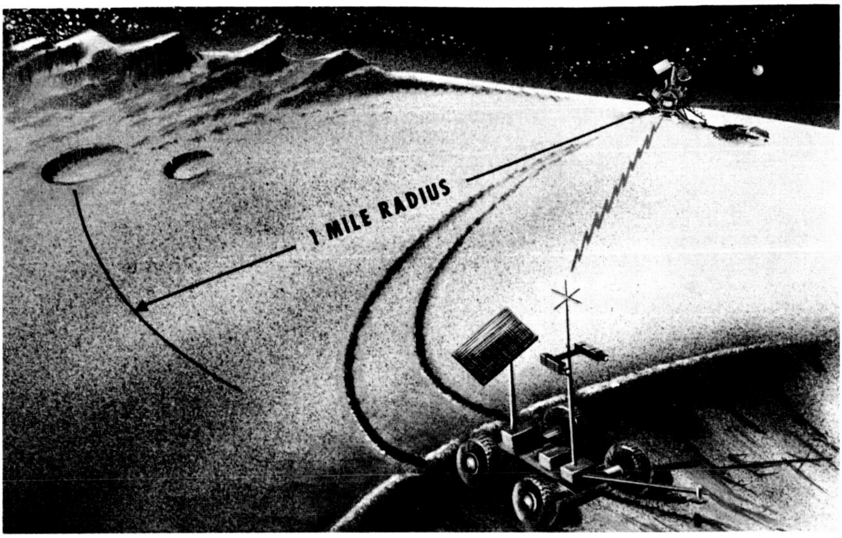


Figure 2–3. Roving vehicle extends Surveyor's lunar explorations.

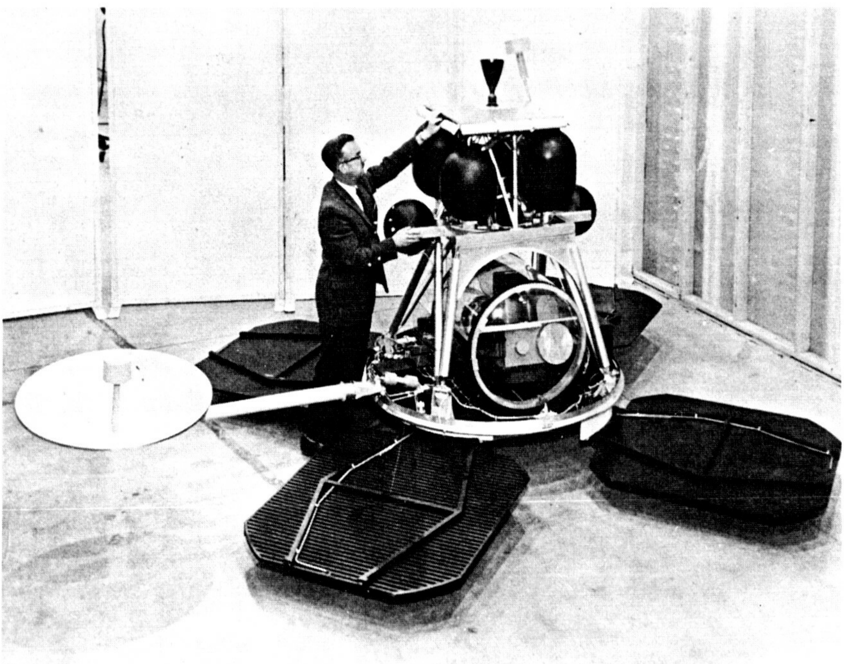


Figure 2–4. Full-scale mockup of Lunar Orbiter.

Bioscience Programs

To help keep pace with technological advances in the Nation's space program, bioscientists planned the first flight of their orbiting biological laboratories (biosatellites) in about 2 years. They also made significant progress in understanding the biological effects of weightlessness, cosmic radiation, gravitational forces, and other outer space stresses on various life forms. Such knowledge is vital to man's exploration of the planets and interplanetary space.

Biosatellites

Acting on the recommendations of its Space Science Steering Committee, NASA selected experiments for the first three payloads to be carried aboard its biosatellites. Chosen from 175 experiments proposed by scientists throughout the United States, the first payload will contain general biology and radiation experiments; the second plant experiments, tissue cultures, and small mammals; and the third, a pig-tailed monkey as the principal experimental specimen. (Each of the three missions will have a backup spacecraft for a total of six flights in the biosatellite series.)

The first series of experiments will be orbited for 3 days to measure any interactions between weightlessness and the effects of radiation from the source inside the biosatellite. Other general biological experiments of this first payload will be shielded from the radiation source to determine short-term biological effects of weightlessness on plants and simpler life forms.

Another biosatellite will be in orbit for 21 days to test the effects of weightlessness on plant growth, on the structure and division of human cells in a tissue culture, on bone and muscular structure, and on organisms removed from earth's influence. The mission with the primate will investigate the effects of weightlessness on the circulatory and nervous systems and on behavior during the 30-day orbit. The primate will be studied before and after the flight for loss of calcium in the skeleton and various metabolic changes.

In March, a contract was signed for the design and fabrication of the six biosatellites, and negotiations were completed between the Ames Research Center and the Air Force for aerial recovery of the spacecraft.

Environmental Biology

Preparing for the flight of the first biosatellite, environmental biologists were investigating the effects of weightlessness, radiation, gravity, magnetism, and other space environmental factors on various life forms by simulating as many as possible of these conditions in ground-based laboratories.

During the first 6 months of 1964, significant progress was made in these investigations. For example, instruments were developed for automatic measurements of the circulatory system and metabolism of primates which will orbit the earth for 30-day periods. Thorough laboratory studies of the effects of the space environment on a variety of plants and animals were undertaken by NASA contractors and grantees. At the E. O. Lawrence Radiation Laboratory (University of California, Berkeley) fruitflies exposed to radiation partially recovered when brought into contact with a constant magnetic field up to 9,000 gauss. Experimenters at Ohio State University found that mice better survived exposure to one atmosphere of 100-percent oxygen when they were exposed daily to normal air, even for a period of only 2 hours. An 8-hour daily exposure to 100-percent oxygen resulted in greater changes in the bodies of the test animals which were counteracted rapidly by their exposure to air. Results of the experiments supplied a key to an astronaut's chances of surviving in a space capsule which is limited to a closed environment of this enriched oxygen.

In tests in a simulated Martian environment to find out if earth's life forms could live to contaminate that planet, more than two dozen species of bacteria survived for as long as 10 months. Their survival varied greatly according to the rate of freezing and thawing of the water in which they were growing and reproducing.

Behavioral Biology

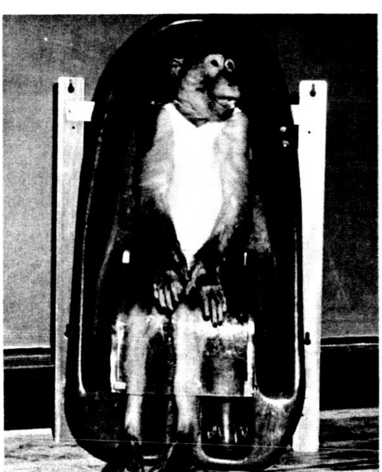
Because spacecraft carrying biological specimens are subjected to high rates of spinning before they are injected into orbit and on reentry into the earth's atmosphere, University of Kentucky biologists completed studies to find out how much of this "spin-up" test animals, such as mice, can tolerate. Results of other investigations, using a special centrifuge designed by university experimenters (described in the *10th Semiannual Report*), were being analyzed. Information supplied by experiments of this type should help builders of spacecraft determine how space capsules need to be designed if orbiting astronauts or other life forms are to function efficiently in space.

Vestibular Response During Weightlessness.—A biological model was designed to allow bioscientists to investigate space sickness, loss of equilibrium, or any other "vestibular" disorder experienced by test animals due to weightlessness in flight.

Processing Pictures by Computers.—NASA joined the National Institutes of Health, the National Science Foundation, and the Department of Defense in developing computers able to perform certain "human" operations such as image detection and noise reduction. Progress was made toward improving the quality of images and building motion picture sequences from a small portion of information from each frame.

Instruments Measure Biological Rhythms.—Biologists at Princeton University and electronic engineers at Franklin Institute (Philadelphia) cooperated in designing and building two instruments which can record the effects of the earth's rotation on the biological rhythms of various life forms while they are orbiting in outer space. One is a highly sensitive electronic device called an "actograph" to measure the activity of small organisms; the other a miniaturized implantable instrument to record the temperatures of animals.

Cardiovascular System Study.—The chimpanzee Enos was orbited on November 29, 1961, in a Project Mercury capsule to simulate as nearly as possible conditions expected for the Nation's first manned space flight (Astronaut John Glenn, February 1962). In attempting to explain the high blood pressure detected in Enos, cardiovascular experts at the University of Southern California produced persistent hypertension in laboratory chimpanzees restrained and required to



PRIMATE IN RESTRAINT SEAT

CATHETER IMPLANTS IN ARTERY AND VEIN

Figure 2–5. Cardiovascular system studied during weightlessness.

perform the same demanding tasks as was Enos. These findings show promise of an increased understanding of the cardiovascular system.

Exobiology

Success marked all tests to date of the radioisotope biochemical probe Gulliver (described in NASA's *10th Semiannual Report*, ch. 2) being developed by exobiologists to study extraterrestrial life forms. An experimental model of the Wolf Trap—another life detection device under development—will be field tested before a flight prototype is built. (See fig. 2–6.) This instrument, devised by Dr. Wolf Vishniac of the University of Rochester (New York), uses a vacuum to draw soil samples into bacteriological culture media, such as beef broth or nutrient broth. When living organisms are trapped, the culture broth becomes cloudy or undergoes acidity changes.

Other devices under development to search for living organisms on other planets or in interplanetary space include a miniature laboratory (Multivator) to conduct several biochemical or biological experiments on Mars, a high-resolution vidicon (TV) microscope, a spectrophotometer that uses ultraviolet radiation to detect Martian life, and a gas chromatograph to identify biologically significant molecules. The gas chromatograph is not a real "life detection" device but rather an

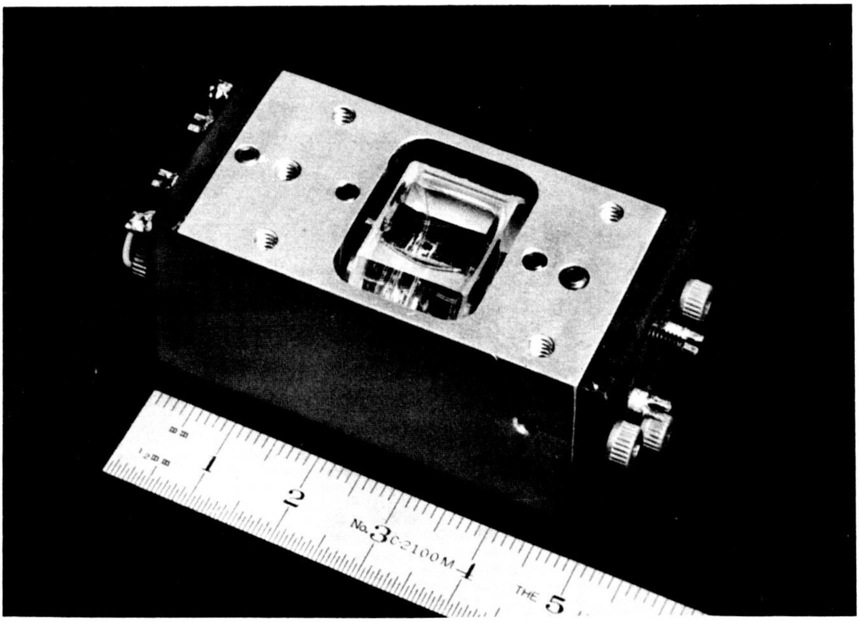


Figure 2–6. Wolf Trap for life detection.

instrument able to establish the presence of organic molecules in outer space that are also found in life on earth.

Planetary Quarantine

The Jet Propulsion Laboratory was designing a spacecraft sterilization facility to help keep earth's micro-organisms from being carried aboard spacecraft to contaminate other planets. These microbes must be removed or killed during spacecraft manufacture. During the report period, JPL scientists set up facility requirements to assure biocleanliness during manufacture by analyzing the source and pattern of biological contamination on parts, tools, clothing, air, and on human skin, and then developed methods to check or remove such contamination. In addition, the U.S. Public Health Service—through its Communicable Disease Center Laboratory at Atlanta, Ga.—agreed to conduct research on sterilization problems for NASA. The Center will also produce training materials and provide a staff to operate a microbiological laboratory for sterility testing of space hardware.

Physical Biology

NASA's *10th Semiannual Report to Congress* described a 120-day study in nutrition for manned space missions and animal experiments in space. In this experiment 15 volunteer prisoners were fed a chemically defined liquid diet of pure amino acids, vitamins, carbohydrates, and necessary minerals. They experienced neither appreciable weight loss nor major medical difficulties during the test period. The testing period, when extended to 6 months, resulted in generally improved health for the men and no injurious side effects. Experimenters found ways of storing these diets so that they are not damaged by radiation, humidity, or temperature. The diets are very compact—a cubic foot, including 50 percent water, can supply 2,500 calories a day for about a month.

In another development an automatic electronic scanner and computer, which may be adaptable for use with life detection systems, was being designed to monitor blood cells and chromosomes.

Manned Space Science

Since the fullest possible scientific exploration of space depends on including recognized scientists as astronauts, NASA, in cooperation with the National Academy of Sciences, set about determining standards for their selection. (See also ch. 1.) In addition the Agency, cooperating with the Nation's scientists, continued to strengthen its science programs by providing for the planning and development of space science investigations which will make maximum use of the astronauts' ability to perform efficiently in space.

Early in 1964, the preparation of inflight scientific experiments for Gemini missions began under NASA's manned space science program. Flight qualification testing of equipment for these experiments—slated to fly on the first two-man Gemini spacecraft—began in June (ch. 1). Scientific experiments were approved for seven later manned Gemini flights, and scientists from university and other laboratories who will develop these experiments and analyze their results began preparing the required equipment.

As the first manned flight of Project Gemini drew near, space scientists increasingly turned their attention to the planning of more sophisticated scientific experiments to be performed on the Apollo program's manned earth-orbiting flights preceding the manned lunar mission. In June, scientists gathered at the Manned Spacecraft Center to review the Apollo lunar mission flight plan and to begin detailed planning of investigations to be carried out by astronauts in early manned lunar exploration.

NASA, through a grant to the U.S. Geological Survey, continued to support the most comprehensive topographic analysis of large areas of the moon's surface yet undertaken. The data will serve to guide Lunar Orbiter spacecraft in photographing the terrain to pinpoint likely landing sites for Surveyor spacecraft and Apollo astronauts.

Medium Launch Vehicles

During the first 6 months of 1964, NASA used the Scout, Delta, Agena, and Atlas-Centaur medium launch vehicles to orbit spacecraft in its space science and applications programs.

Scout

A Scout successfully launched the second Ariel United States-United Kingdom international satellite on March 27 (p. 63) from the Agency's Wallops Island, Va., facility.

Delta

On January 21, a Delta launch vehicle orbited the Relay II communications satellite. Another Delta, on March 19, failed to orbit the Polar Ionosphere Beacon due to a malfunction during the third stage powered flight. This was the first failure after 22 consecutive successes with this launch vehicle. (Another Ionosphere Beacon was being prepared for launching later in 1964.)

Agena

A Thor-Agena placed the Echo II passive communications satellite into orbit in January (p. 87), and the Atlas-Agena launched Ranger VI on its trip to the Moon on February 2 as planned (p. 65). In addition, an Atlas-Agena launched Fire I to investigate high reentry velocity into the earth's atmosphere (37,000 feet a second) in a test from the Atlantic Missile Range in April. Data from the flight were being analyzed.

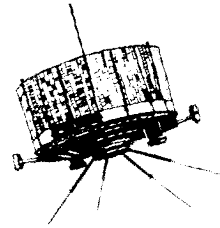
Improvement Program.—The first improved Agena D vehicles, developed in a joint NASA-Air Force program, were being readied for flight. The first Air Force launch of the vehicle was successfully completed late in the second quarter of 1964, and the first NASA flight was scheduled for the third quarter of the year.

Standard Atlas Development.—A NASA-Air Force standard Atlas improvement program neared completion. The first standardized Atlas vehicle—eventually to be used for all Air Force and NASA space programs in the Atlas-Agena payload class—was completed in June and will be flight tested during 1964.

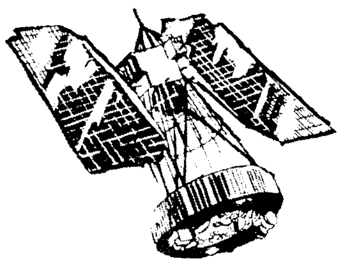
Launch Vehicle Status.—Atlas-Agena and Thor-Agena were being prepared to launch a lunar photographic mission, an Orbiting Geophysical Observatory, a weather satellite, and two Martian fly-by missions. Launchings were scheduled for the third and final quarters of 1964.

Atlas-Centaur

Atlas-Centaur, the first U.S. launch vehicle to use liquid hydrogen as a fuel, will carry Surveyor spacecraft to the Moon, advanced spacecraft to Mars, and launch other satellites and space missions. Second and third development flights occurred in November 1963 and June 1964, respectively. Extensive ground testing concentrated on the insulation panels and nose fairing which were jettisoned in space for the first time on the June development flight. The fourth Atlas-Centaur was completed and shipped to the launch site at Cape Kennedy. The development program for Atlas-Centaur will be completed in 1965, and the vehicle will be ready to carry Surveyor early in that year.



3 SATELLITE APPLICATIONS



During the first 6 months of 1964, Relay II and Echo II became the latest additions to NASA's communications satellite family joining Telstar II, Syncom II, Relay I, and Echo I in providing data for scientists, engineers, and others experimenting with these spacecraft. In addition, substantial advances were made toward a worldwide communications satellite network when the Communications Satellite Corporation announced that it would soon proceed with an experimental-operational system at synchronous altitude and offered its first stock for sale.

Satellites and sounding rockets in NASA's meteorological programs provided meteorologists all over the globe with invaluable data for research and for weather analysis and forecasting. The first experimental Automatic Picture Transmission (APT) subsystem aboard TIROS VIII supplied forecasters with photographs of local cloud cover and the conventional TV camera carried by this latest in the meteorological satellite series continued to transmit pictures of good quality after over 6 months of operation.

Meteorological Programs

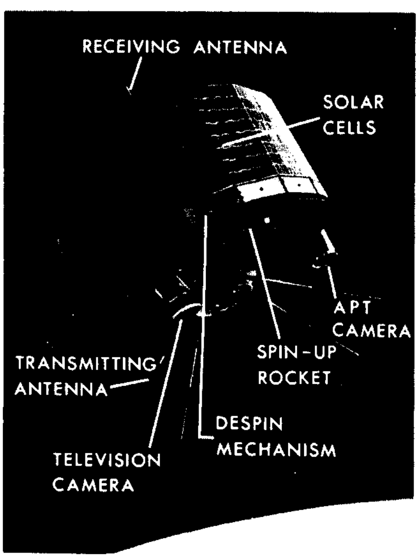
Progress in space technology during the report period continued to offer unique advantages for research and operational meteorologists.

The APT subsystem, for example, supplied forecasters in remote areas with data on local cloud cover a few minutes after photographs were taken, whereas under present data relay systems forecasters must wait 3 to 6 hours for this information.

TIROS

During the first week of May 1964, TIROS VII (launched June 19, 1963) established a new record of performance in this highly successful satellite series when it exceeded the 66,674 pictures (59,830 of them meteorologically useful) taken by TIROS VI. The seventh TIROS also continued to supply infrared radiation data of good quality. Its instruments had already provided information on this type of radiation for more than twice as long as that furnished by similar instrumentation aboard TIROS II, III, and IV.

On December 21, 1963, the eighth TIROS, carrying the first experimental Automatic Picture Transmission (APT) subsystem, was orbited and began transmitting. This subsystem—described in detail in the *10th Semiannual Report*—was undergoing extensive qualification tests aboard TIROS VIII prior to use aboard the polar-orbiting Nimbus for which it was designed. APT will enable meteorologists to use relatively simple and inexpensive ground equipment to receive local cloud cover pictures as the satellite passes overhead instead of



GROSS WEIGHT	265 LBS.
INSTRUMENT WEIGHT	51 LBS.
SENSORS	1 TV CAMERA 1 AUTOMATIC PICTURE TRANSMISSION SYSTEM
POWER	20 WATTS
STABILIZATION	SPIN
DESIGN LIFE	4 MONTHS
LAUNCH VEHICLE	DELTA
ORBIT	APOGEE 470 MI. PERIGEE 440 MI. INCLINATION 58.5°
STATUS	TIROS VIII LAUNCHED 21 DEC ,1963

Figure 3–1. TIROS VIII with APT subsystem.

depending on data relay from a large command and data acquisition station.

Over 40 ground stations of the Departments of Commerce and Defense and of several foreign countries were receiving and using data from this APT subsystem experiment. (Some nations have built their own ground stations for this purpose.) Reception, as with many experimental systems, depends on the skill of the ground station operator to a considerable extent.

The irregular lines (scalloping and banding) of the illustration (fig. 3–2) resulted from the interaction of the earth's magnetic field on the electron beam of the APT TV camera aboard the spacecraft as the satellite spun. This would not occur when the APT subsystem is aboard the earth-oriented Nimbus, since Nimbus will not spin.

The next in the TIROS series, being prepared for launch as TIROS I (Eye), will be built like a cartwheel with the cameras looking out through the sides instead of through the base. This satellite, shown in fig. 3–3, p. 81, will be initially orbited as were the other TIROS satellites. However, after about the fourth orbit, it will be rotated in space so that it will roll along like a wheel. Since the spacecraft's spin axis will be perpendicular to its orbital plane, each camera can look straight down at the earth once during each revolution of the satellite. This will permit earth-oriented pictures throughout the sunlit portion of each orbit. TIROS I is planned for a near-polar, sun-synchronous orbit to acquire data from the polar regions. In this orbit it should

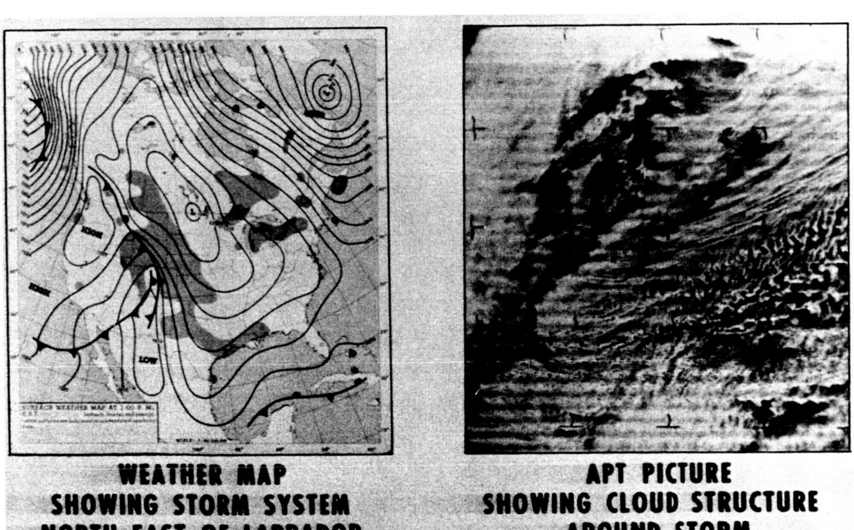


Figure 3–2. First flight demonstration of APT subsystem.

provide almost complete coverage of the sunlit portion of the globe daily and serve as the basis for the TIROS Operational Satellites (TOS).

A Weather Bureau-funded operational meteorological satellite system, based on the highly successful TIROS technology, will be set up to provide data for weather analyses and forecasts. This TIROS Operational Satellite (TOS) system, a cooperative NASA-Weather Bureau program, has as its primary objective obtaining cloud picture coverage of the entire sunlit portion of the earth at least once a day on a regular and continuing basis. The system, to assure maximum success at minimum cost, would use proven meteorological satellite technology. Under this program NASA will design, develop, and procure the spacecraft, launch them into orbit, design and construct the ground receiving stations, and provide tracking data. The Weather Bureau will set up the meteorological requirements, operate the ground stations, and process and disseminate data.

Nimbus

The Nimbus project would further advance the science of meteorology by developing, launching, and operating a series of advanced meteorological observatories in space. During the report period, the prototype Nimbus spacecraft passed its qualifying tests and was shipped to the Western Test Range (Point Arguello, Calif.) to be tested with the launch vehicle before the flight spacecraft is mated to the vehicle. Nimbus A—the first flight spacecraft—was being prepared for shipment to the range for a scheduled launch during the third quarter of 1964. A backup spacecraft was being prepared for launch, if needed.

These spacecraft incorporate two basic improvements over TIROS—they are stable platforms in space pointing earthward at all times, and their design incorporates functional flexibility. (See also the *9th* and *10th Semiannual Reports.*) Nimbus A will carry sensors of three types: An advanced three-camera TV system to provide cloud cover pictures; special high resolution infrared radiometers to supply nighttime cloud cover data; and an Automatic Picture Transmission subsystem which was flight tested on TIROS VIII. (Nimbus A was successfully orbited as Nimbus I on August 28.)

Meteorological Sounding Rockets

NASA's *Ninth Semiannual Report* (ch. 3) outlined the uses of large and small meteorological sounding rockets to measure and study the structure and dynamics of the atmosphere between 20 and 70 miles

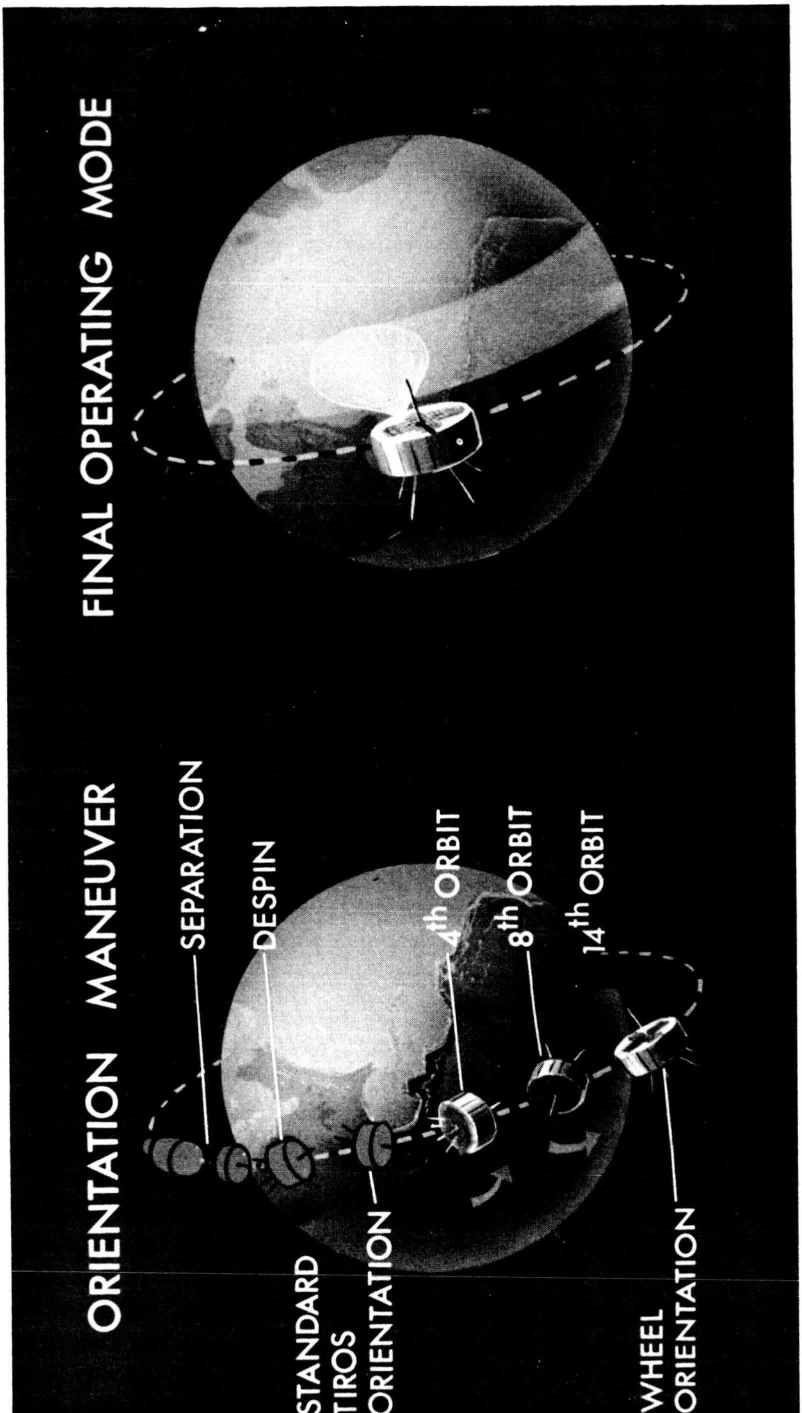


Figure 3–3. The cartwheel TIROS I (Eye).

above the earth. During the first 6 months of 1964, the Agency requested industry to submit proposals for a study of a second generation of these small sounding rockets which would eventually comprise an inexpensive, self-sufficient rocket system suitable for routine use in an operational network. The study, designed to define the general characteristics of rockets of this type, would be based on flight tests of the Arcas and Loki class rockets now in use.

The period also witnessed the flight of experiments aboard three large meteorological (Nike-Cajun type) rockets—one carrying acoustic grenades, another using a sodium-vapor trail, and a third carrying a pitot-static tube. Twenty-one of these rockets were launched to study such factors as geographical and seasonal variations in the atmosphere and the cause of unusual temperatures and temperature variations in winter at about 40 miles above the globe. Launches were made from Wallops Island, Va., Fort Churchill, Canada, and Ascension Island in the South Atlantic.

Supporting Research and Technology

The following are some of the objectives of supporting research and technology for NASA's meteorological programs: To develop sensors, controls, and data acquisition systems; improve future systems by studying data provided by past and present satellites and sounding rockets; evaluate further experiments and uses for a given system; and investigate new concepts or applications of potential value for future systems. Two examples of this research and technology are further improvement of TV cameras which have performed so well aboard TIROS and the development of improved high resolution infrared radiometers to supply better nighttime cloud cover data.

Long-range engineering plans for better camera systems include such refinements as direct data-storing systems, continuous day and night cloud coverage, continuous automatic direct readout with simplified ground systems, single-line scanning photographic techniques, lightweight designs, lower power drain, and rugged, miniature picture tubes. In addition, a camera was being developed which is highly sensitive to very little light. A more revolutionary type—the dielectric tape camera planned to be ready in 2 years—will use a moving electrostatically charge tape to record inside the vacuum camera enclosure the substantial data provided by an external scanning optical system (fig. 3–4).

A recorder using a quarter-inch, 1,200-foot endless loop tape was developed for the high resolution infrared radiometer. It will store up to 128 minutes of infrared and timing data on night cloud coverage and offer fast start-stop capability, better performance, and longer life over equipment now in use. Also, the University of Chicago, under a NASA contract, determined a method of combining information from several channels of the infrared radiometer with cloud photographs to supply more data on the amount of cloud cover and cloud height than a separate analysis of either of these data sources could provide.

Figure 3–4. Research and technology support meteorological systems.

Communications and Navigation Programs

Communications satellites provided U.S. TV viewers with coverage of the winter Olympics at Innsbruck, Austria, and an estimated 165 million Europeans watched the world's heavyweight boxing match telecast from this country in the spring.

In its navigation satellites program NASA joined with the Departments of Defense, Interior, Commerce, Treasury, and the Federal Aviation Agency in setting up an ad hoc Joint Navigation Satellite Committee to consider a system of spacecraft able to meet future air-sea navigation and traffic control needs.

Communications Satellite Corporation

In January NASA agreed to requests of the Communications Satellite Corporation for reimbursable launchings and related support services for the Corporation's early experimental-operational global communications system. Under the terms of this agreement the Agency will—

- Provide improved Delta launch vehicles to launch the communications satellites into transfer orbits with very low inclination;

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- Provide facilities and support for prelaunch integration and checkout of payloads for the Corporation's satellites at the Atlantic Missile Range; and
- Track the satellites during their initial transfer orbits.

NASA, in addition to consulting frequently with the Communications Satellite Corporation, served as a technical adviser to the Federal Communications Commission on this experimental-operational system. Furthermore, to respond better to FCC requests for this technical advice, the Agency redirected some of its study contracts.

Time Delay and Echo Tests

The problem of suppressing delayed echoes experienced in telephone calls via long underseas cables and high satellites was detailed in the *10th Semiannual Report* (ch. 3). Results of an FCC–NASA "real user test program" to test subscriber reaction to time delay and echo

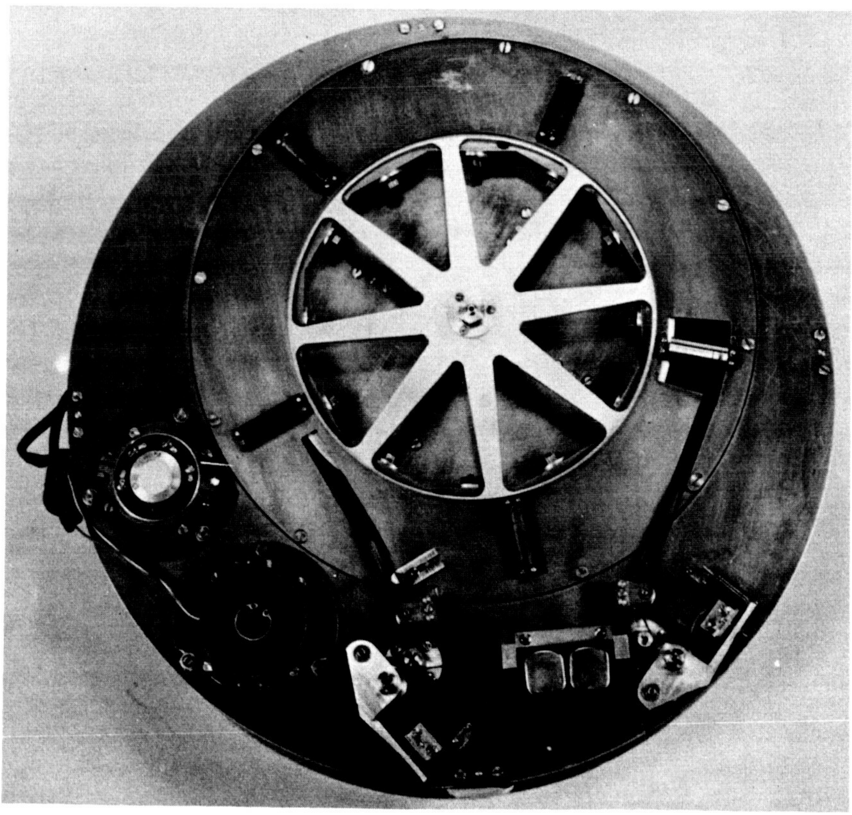


Figure 3–5. Endless loop tape recorder.

became available during this report period. Although not yet completely evaluated, these test results have led the United States to take the position that the 300-millisecond normal maximum round-trip delay recommended by the Consultative Committee for Telephone and Telegraph, International Telecommunications Union, is premature, and that further understanding of the problem would result from experience gained after the early operational system is established.

Active Communications Satellites

In January, Relay II, a wide-band active communications satellite was orbited. The spacecraft performed as planned during this report period. In addition, Telstar II continued to operate successfully as it completed its first year in space in May, and Relay I continued to exceed its designed lifetime of a year. Further, Syncom II supplied thousands of hours of experiments, and, at the request of the Defense Department, was moved toward and beyond the international date line.

Telstar.—On April 16, Telstar II for the first time linked Japan and Europe via communications satellite and provided 60 public demonstrations dramatizing the possibilities of this type of spacecraft. This second Telstar—launched May 7, 1963—also supplied radiation data which gave observing scientists a more accurate understanding of the Van Allen radiation belt.

Relay.—Scheduled to be turned off by an onboard timer in December 1963, Relay I became the first communications satellite to exceed its designed lifetime in orbit when the onboard timer failed to stop the spacecraft from transmitting.

Relay II was orbited from Cape Kennedy on January 21, 1964. A Delta launch vehicle boosted the spacecraft into an orbit with a higher perigee than the first Relay (1,298 rather than 822 miles). However, the two satellites have the same apogee—4,600 miles—providing longer periods for both of them to be visible between ground stations. Numerous changes and improvements were incorporated in the second Relay based on operating experience with the first. Among these were improved solar cells more resistant to radiation damage; changes in power circuitry to prevent the runaway leakage of Relay I; reduced command circuitry sensitivity minimizing the possibility of spurious commands from radio frequency interference; and improved radiation detectors.

Two new Relay ground tracking stations began operating during April—a narrowband station south of Madrid, Spain, operated by Compañía Telefónica Nacional and a second wideband station near Tokyo operated by the Japanese Government's Radio Research Laboratories.

Syncom.—The launching of Syncom III, scheduled for May, was delayed pending the investigation of an accident on April 14, at Cape Kennedy, which occurred during the mating of an Orbiting Solar Observatory spacecraft to a Delta launch vehicle (ch. 2). Syncom C (Syncom III after launching) was to be placed into a synchronous orbit of near zero inclination by an improved Delta vehicle, resulting in its "hovering" over a point on the equator rather than describing a figure 8 as Syncom II does. (The spacecraft was launched into its planned synchronous stationary orbit from Cape Kennedy on August 19.)

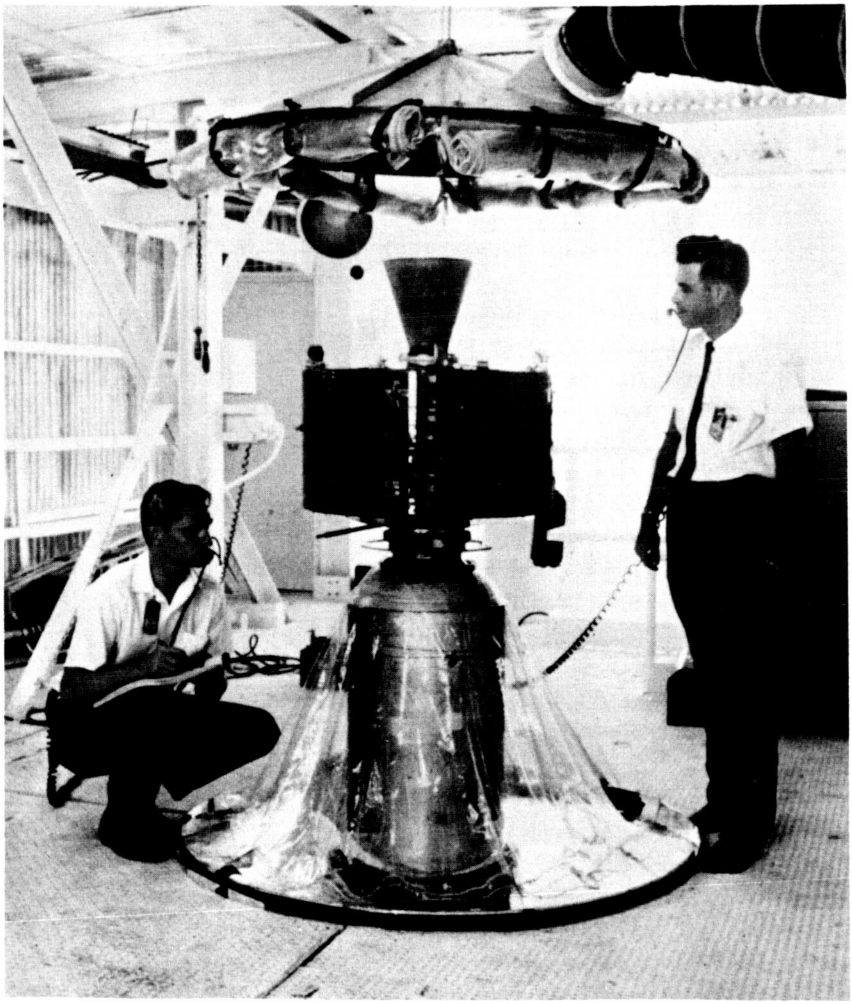


Figure 3–6. Syncom II mated to Delta third stage.

To meet the needs of the Defense Department for satellite experiments, Syncom III was to be placed on station near the international date line, while Syncom II was to be allowed to continue its drifting to a position over the Indian Ocean. Accordingly, Syncom II was commanded on March 17 to drift westward at a rate of 1.3° a day. The delay in the launch of Syncom C, however, made it necessary to slow this drift rate to be certain that Syncom II would be at a supporting location near 165° east longitude when Syncom C was launched. Tests with Syncom II continued during the report period, as the spacecraft logged over 2,000 hours of communicating time.

Passive Communications Satellites

NASA, through its Project Echo, has established the feasibility of erecting large reflecting spheres in space to be used as passive communications satellites. Echo I, launched August 12, 1960, was still orbiting although its usefulness as a communications link was limited since it was wrinkled and partially collapsed.

On January 25, Echo II, a larger rigidized sphere, was launched into polar orbit by a Thor-Agena rocket. (The satellite was described in detail in *Semiannual Reports 5* through *10*.) A TV camera in the Agena second stage showed the inflation of the sphere as it passed the east coast of Africa. The new controlled inflation system functioned properly. The reflection characteristics of the 135-foot sphere indicate that it began to spin at about 0.6 of a revolution a minute shortly after inflation. Studies to determine the cause of this spin were undertaken.

In addition to communications experiments in this country, arrangements were made for Echo II cooperative experiments with the U.S.S.R. under the terms of the bilateral agreement of June 1962. Accordingly, nine Soviet stations reported optical observations during the satellite's early orbits and sent several original film negatives to NASA for analysis. Further communications tests were conducted via the second Echo from February 21 through March 8, 1964. The British Jodrell Bank radio telescope—operating on behalf of NASA for these tests—transmitted signals at 162 megacycles to be received by the Zimenki Observatory of Gorki State University east of Moscow. Thirty-three tests took place in this series including 400-cycle tone, teletype, slowed down voice, and facsimile. Incomplete evaluation of the results reported on the experiments indicates performance below that expected. Discussions were held with the Soviet Union concerning the possibility of a second set of experiments.

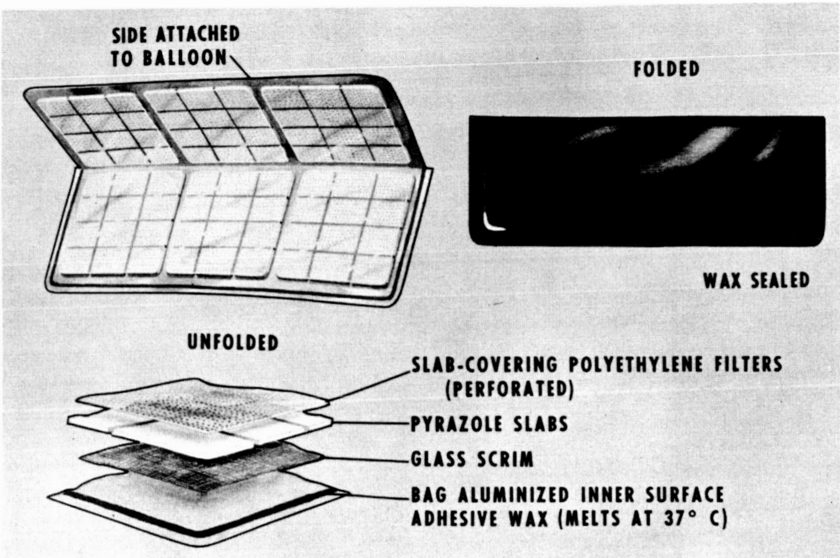


Figure 3–7. Echo II controlled inflation system.

Navigation Satellites

After extensive studies completed during the first 6 months of 1964, NASA concluded that it was feasible to use communications satellites to serve as nonmilitary air-sea navigation, rescue, and traffic control aids. It was further concluded that this system could function on a worldwide basis during all kinds of weather for craft ranging from supersonic transports to small oceangoing vessels. Results of the studies were distributed to other Government agencies and to aerospace companies for review and comment.

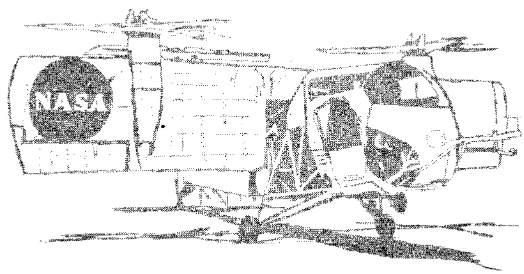
Based on results of the same studies the Departments of Defense, Interior, Commerce, and the Treasury, along with the Federal Aviation Agency, were invited by NASA to form a Joint Navigation Satellite Committee to evaluate requirements for a satellite system to meet future air-sea navigation and traffic control needs; determine if this system would be in the national interest; and recommend research and development programs for each participating agency. Planning was underway to incorporate into one of NASA's Advanced Technological Satellites (described in the following paragraphs) equipment and instrumentation which could conceivably be used in certain navigation spacecraft.

Advanced Technological Satellites

The report period saw plans completed for the Agency's Advanced Technological Satellites (ATS) Program and an Advanced Technological Satellite Flight Project established under the management of Goddard Space Flight Center. (See also the *10th Semiannual Report*, ch. 3.) Using technology developed under Advanced Syncom, the ATS Project would conduct research and development, and flight test promising technology for numerous applications, particularly for stationary orbit; investigate passive gravity-gradient stabilization methods; and conduct flight experiments in several types of satellite applications on each spacecraft.

Each Advanced Technological Satellite will be able to adapt itself to various types of payloads and is being designed for a 3-year lifetime. Among experiments to be orbited on the spacecraft are ones in communications, meteorology, and orbital environment. The first flight of the ATS series is planned for 1966. It will be a carefully instrumented experiment in gravity-gradient stabilization at an altitude of 6,500 miles. Four flights are planned at synchronous altitudes, two spin-stabilized in 1967 and two earth-oriented in 1968.

4 ADVANCED RESEARCH AND TECHNOLOGY



In carrying out its responsibilities in basic research, engineering research, and experimental subsystem development, NASA's Office of Advanced Research and Technology strives to enlarge scientific knowledge, create engineering design principles, and pave the way for the orderly development of aeronautical and space systems.

The Agency's advanced research and technology efforts embrace the broad fields of space power technology, space vehicles, spacecraft electronics and control, aeronautics, biotechnology and human research, advanced propulsion systems (nonnuclear), and basic research. Each of these includes specific areas where continuing investigation is fundamental to the success of future missions.

Space Power Technology

During this period, a study of the entire national space power systems research and development program was initiated under the auspices of the Aeronautics and Astronautics Coordination Board. NASA and the DOD, in cooperation with the AEC, reviewed all solar, chemical, and nuclear research and technology efforts related to space power systems to determine their adequacy, timeliness, and balance in relation to anticipated needs. Industry and universities prepared and reviewed a number of basic technical papers for the four panels which analyzed the activities.

Solar Cells

Solar cells continue to be the most common source of power in space. During this period, work continued on the evaluation of experimental radiation-resistant solar cells and development of the reverse structure phosphorus diffused solar cell described in the last report. Over 10,000 such cells will be flown on the Nimbus A scheduled for launch in 1964.

A series of balloon flights was completed to provide solar intensity standards which will be used in solar simulator and terrestrial sunlight measurements of solar cell and solar array power producing capability.

Inhouse efforts at the Goddard Space Flight Center and at JPL encouraged solar cell manufacturers to reduce the weight of the cell by 50 percent and to eliminate one process. Steps were also taken to initiate a program on improved fabrication techniques for solar arrays with special emphasis on improved packaging during launch.

Thermionics

In this field, the most significant advance was the demonstration in laboratory tests at JPL of a thermionic generator with conversion efficiency exceeding that of present solar cells. In addition, experiments on a new thermionic diode, the basic unit from which the generator is fabricated, indicated the possibility of achieving even greater efficiency. And research studies of a more basic nature suggested that further improvements could result from the use of additives in the diodes.

Solar Collectors

In conjunction with the solar thermionic work, experiments were continued on methods of fabricating light-weight, high-precision mirrors for focusing solar energy. Spin casting of mirror masters, a relatively inexpensive process, was found to have possibilities for both thermionic and solar dynamic systems. A 9.5 foot diameter mirror fabricated by this process was tested in sunlight.

Solar Dynamic Systems

The laboratory experimentation phase of the Sunflower research and development effort was completed and topical reports were being prepared. The test results identified the major problems which would require resolution should a complete Mercury-Rankine power generation system be specified for space missions. No further work is planned at this time.

Work continued on identifying and resolving the major technological problems associated with a closed-cycle argon-Brayton power generation system. Test loops were being erected at the Lewis Research Center to test the system's principal components which were being designed and fabricated by industry. The basic power conversion equipment for the Brayton cycle may be adaptable at several power levels using solar, chemical, or nuclear energy sources.

Chemical Dynamic Systems

Work was in progress on an internal combustion engine-generator set capable of operating on hydrogen and oxygen. It may be used as an emergency power unit for manned space vehicles which will use hydrogen and oxygen in conjunction with a fuel cell.

Power Distribution and Control

Progress was made in developing experimental d.c. to d.c. converters suitable for converting to useful voltage levels the low level d.c. voltages associated with direct energy conversion devices such as solar cells, thermionic diodes, thermoelectric couples, batteries, and fuel cells. Parallel operation of these devices offers the advantages of greater reliability and improved performance, but until recently it appeared impractical because of the inefficiency in converting low level d.c. voltage to a useful level. An experimental converter was operated at 86 percent efficiency with an input of 0.7 volts and an output of 30 watts at 51 volts.

A series of solid-stage current limiters was developed. They cover the range from $\frac{1}{16}$ amp to 5 amps and will be useful for protection of spacecraft electrical circuits.

Space Vehicle Systems

Advanced Concepts

Lifting Body Spacecraft Program.—NASA's research program on advanced lifting body spacecraft (capable of appreciable maneuverability during atmospheric reentry flight as well as conventional runway landing) has four basic objectives: To investigate approach and landing characteristics, emphasizing realistic minimum landing lift-to-drag ratio requirements, rocket augmentation while landing, piloting procedures, and visibility constraints; to evaluate general handling qualities of the lifting body class of vehicles over a wide range of angles of attack; to determine flight control system requirements; and to correlate wind tunnel and flight characteristics.

During the period, the program, extended with additional manned flight tests, reached a total of over 100 low-speed manned flights. All flights were completed at the Flight Research Center with a light weight vehicle of the Ames M–2 configuration. (Fig. 4–1).

For the added manned flight tests, two heavier weight vehicles of the Ames M–2 and Langley HL–10 configurations were being procured. (Fig. 4–2.) The M–2 configuration is basically half of a 13-degree cone which has been sliced along the longitudinal axis with a canopy added for pilot visibility and twin tails for stability and control. The HL–10 (fig. 4–3) is essentially a highly swept, very thick, inverted delta wing with a large center fin and two smaller outboard tails for stability and control. Each vehicle is to be approximately 20 feet long, weigh about 4,400 pounds, and capable of accepting up to 4,000 pounds of ballast to vary wing loading and center of gravity location during the test program.

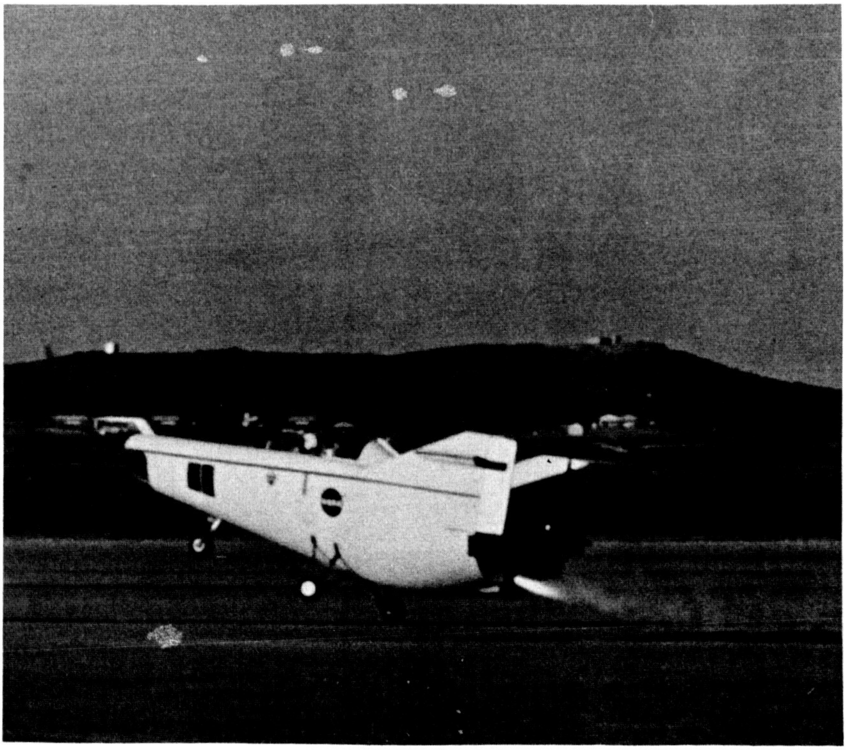


Figure 4–1. M–2 research vehicle landing at Edwards Air Force Base.

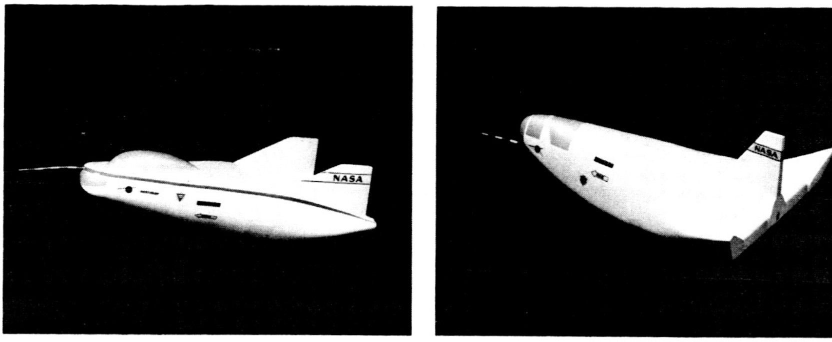


Figure 4–2. Models of the heavier M–2 and HL–10 (left to right).

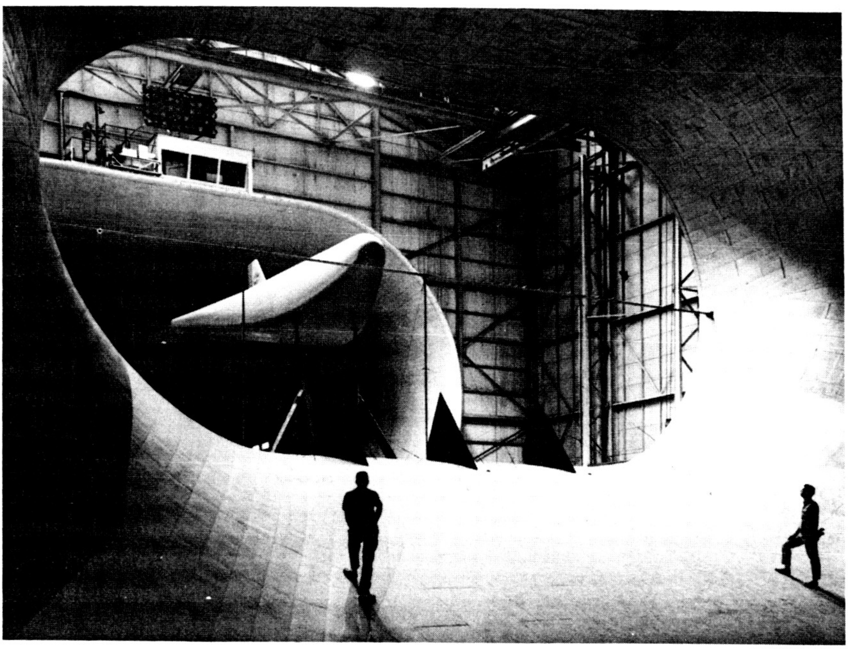


Figure 4–3. Large HL–10 model in Langley wind tunnel.

The Ames, Langley, and Flight Research Centers cooperated in supplying the design data for the spacecraft. The flight vehicles will be thoroughly tested in the Ames 40 x 80-foot wind tunnel before tests at the Flight Research Center. In flight testing, the craft will be carried aloft by a B–52 carrier, released at a Mach number of about 0.8, and then, under pilot control, glide to a landing at Edwards; research information will be gathered during all phases of the return flight.

Spacecraft Landing and Recovery.—As part of this continuing program, Langley Research Center completed a series of successful flight tests of a balloon which achieves its buoyancy from hot air. For spacecraft or booster recovery, the balloon can be stowed in a container and deployed at the appropriate altitude much like a parachute. By means of a propane (or other suitable fuel) burner located beneath the open balloon mouth, an astronaut (or automatic programer for unmanned versions) can control the rate of descent or even hover for a period. This type of system would allow the pilot of a spacecraft to select a more advantageous landing site; it would also permit a soft landing without impact attenuation devices.

Environmental Effects

High Energy Radiation Effects and Shielding.—One of the main objectives of the shielding research program is to determine the amount of secondary radiation produced by high energy protons penetrating space vehicle materials. Theoretical calculations indicated that for present thin wall space vehicles the effect of the secondary radiation dose from Van Allen or solar flare protons will be less significant than the effect of the penetrating protons. These calculations were experimentally verified with proton energies of 160 million electron volts (Mev.) by the Oak Ridge National Laboratory under NASA contract. Experiments at lower proton energies of 15, 30, and 60 Mev. were being conducted at Oak Ridge and at energies of 350 Mev. at the University of Chicago.

Construction of the Space Radiation Effects Laboratory (SREL) near the NASA Langley Research Center progressed on schedule.

Meteoroid Environment and Impact Hazard.—An artificial meteor flight experiment was conducted to provide controlled data on the luminous efficiency of simulated meteors of known mass, composition, material, size, and shape at meteoroid velocities. Two meteors, one of nickel, the other of steel, were simulated. From visual observations, the steel meteor indicated a brighter trace than the nickel. Data from this research will be used with data from the Harvard radio meteor project (discussed in NASA's *10th Semiannual Report*, p. 109) in efforts to measure the mass of meteoroids seen entering the earth's atmosphere.

Three larger Saturn-launched satellites, which will have a meteoroid penetration sensing area approximately 100 times that on Explorer XVI, were being developed, as was another Explorer XVI type spacecraft which should provide additional penetration rates in thin metallic surfaces of another material.

High-Vacuum Technology.—In this continuing program to provide improved laboratory techniques for accurately duplicating and measuring space vacuum conditions and effects, several phases of vacuum technology were studied under contract. Experiments using cesium metal to treat a glass vacuum system showed a marked reduction of pressure due to the lower permeation of helium gas; in addition, cesium treatment of an ion gage heightened its sensitivity and thus increased its ability to indicate lower pressures. The adhesion or cold welding tendency of structural metals in a high vacuum was also investigated; results showed no cold welding for the test samples. Another important study concerned the development of a theoretical model describing the process by which a cold wall (cryopanel) adsorbs and thus pumps gases in a vacuum chamber; results of computer runs demonstrated that the theory can be used to design economical cryopanels for specific applications.

Thermal Radiation and Temperature Control.—In research on passive temperature control systems for spacecraft, a white paint consisting of zinc oxide pigment in a silicone resin vehicle was developed. Although most surfaces alter their characteristics after exposure to the space environment, the white paint proved to be more stable, when exposed to long-term simulated solar ultraviolet radiation, than similar coatings. Consequently, this paint may be used as an external surface for passive control of orbital spacecraft temperatures.

In other studies, it was found that bombardment of spacecraft surfaces by simulated meteroids can alter the surface radiative characteristics but that stainless steel does not alter its ratio of absorbtivity to emissivity under such bombardment.

In research on thermal control surfaces, including metals, these materials were found to degrade when exposed to moderate doses of simulated high energy particle radiation. Further research was planned on this subject.

Efforts to improve simulation techniques and knowledge of degradation focused on two satellites which, when tested under solar simulation before launch were cooler than expected, but were warmer than expected in orbit. This behavior, which could result from inadequate simulation or unexpected degradation of the surfaces in orbit, was being further investigated.

Spacecraft Electronics and Control

Communications and Tracking

A flight test to make measurements relating to the spacecraft reentry communications blackout was completed. The test verified theoretical studies and laboratory investigations for the particular spacecraft configuration and environmental conditions involved.

Studies of the data acquisition capability of ground antennas indicated that it may be impractical to build a single antenna large enough for realtime TV transmission at planetary distances. A study was completed of the feasibility and preliminary design of an array of deep space receiving antennas having an aperture equivalent to that of a single antenna of much larger size.

Microelectronics research moved forward with investigations in a number of fields. Efforts were continued to develop active devices relatively immune to space radiation. At Langley Research Center, the feasibility of obtaining micropower devices in microelectronic form was proved. A study of interconnections included investigations of the state-of-the-art, problem areas, and areas offering the possibility of minimizing interconnections and crossovers and thereby increasing reliability. Research on new packaging concepts continued at the Jet Propulsion Laboratory, Goddard Space Flight Center conducted a program to determine the sensitivity of available microelectronic devices to the space radiation environment, and a physics of failure program investigated the primary failure modes or mechanisms of microelectronic devices with the objective of improving reliability.

Spacecraft Attitude Control

Significant progress was made in developing attitude control components designed to provide long periods of reliable operation in the space environment. For example, a no-moving-part valve was developed for controlling the flow of hydrogen to low thrust attitude control jets. This valve utilizes the controlled diffusion of hydrogen through a palladium alloy membrane as the control mechanism. Also a brushless d.c. motor was developed for orienting solar cell arrays and other payload items aboard spacecraft. This motor, operating without commutators or slipping assemblies, significantly increases power conversion efficiency. And electrical sliprings employing rolling contact elements were tested in a hard vacuum environment. Low noise operation was achieved at speeds up to 5,000 r.p.m., and a technique for replenishing lubrication on the sliprings was devised.

Cryogenic Gyro

Promising results were obtained in the cryogenic gyroscope research project which is jointly sponsored by NASA and the Air Force. Its purpose: To investigate a gyroscope utilizing a superconducting magnetic field to suspend a rotating sphere of niobium in a frictionless bearing. Such a gyroscope offers several advantages: It may simplify guidance equipment, increase its reliability, reduce power required for guidance system operation, and may eventually use readily available cryogenic fuel for cooling.

During this period, laboratory research models were tested, and a gyro drift rate of about 5° per hour was achieved. Although this performance was not competitive with other gyroscopes, the consistency of the drift rate within 0.005° per hour of the 5° rate was outstanding. Subsequent laboratory tests on a crygenically suspended sphere (not a complete gyro instrument) resulted in a total drift of 4° after 3 days or a drift rate of 0.054° per hour. The program was continuing with further research on materials and additional efforts to eliminate development deficiencies.

Instrumentation

NASA centers made significant progress in the development of a number of instruments. One developed by the Marshall Space Flight Center will make it possible to decrease the time lag between static tests of large rocket engines and laboratory calibration of the field instruments used on the test stands. This device is a field calibration standard which optically measures, by interferometer principles, the deflection of a "proving ring" which is deformed by the load. The deflection is directly related to the weight or force sustained by the ring, and the method has demonstrated an accuracy of calibration comparable to that obtained with laboratory devices.

Another instrument was developed by the Langley Research Center in response to a need for rapidly responding force measuring instruments to obtain accurate aerodynamic data in hypersonic wind tunnels where the time span of test runs is on the order of 1/10 of a second. Highly sensitive semiconductor gages were applied to develop a force measuring instrument with response characteristics greatly improved over previous designs using conventional gages. Although semiconductors usually have undesirable temperature characteristics, the temperature changes during the short run time were small, and it was possible to compensate for the temperature influence by properly selected circuit components.

The Marshall Space Flight Center also made progress in the development of an image converter in which a matrix of 25 miniature light-sensitive diodes in a $\frac{1}{8}$-inch square converts visible radiation to electrical energy. An improved conversion gain was obtained by replacing the diodes with transistor triodes. A 50 x 50 array of triodes was being studied and environmental circuitry designed as the next step towards a working module.

In other work at the Langley Research Center a special vacuum gage was developed with a working range of $\frac{1}{1{,}000}$ to $\frac{1}{1{,}000{,}000}$ of one millimeter of mercury; the device can respond to pressure changes over this total range in less than 200 microseconds—a tenfold improvement over previously available gages. It was developed for large test chambers which simulate environmental conditions in near earth orbit and in which rapid changes of pressure must be followed.

Techniques for the fabrication of thermocouples to measure ultrahigh rocket flame temperatures in the 2,500–3,000° C. range were investigated by Marshall Space Flight Center. Tungsten and rhenium used in these specially coated thermocouples were successfully tested in an oxyacetylene flame; they are intended to withstand the oxidizing exhaust of a Saturn vehicle for 5 minutes. Response time of less than 1 second was obtained by a special mechanical configuration.

An improved "leak rate" micrometeoroid sensor was developed by Langley Research Center. An advance on the micrometeoroid pressurized cell detectors used on Explorer XVI, this sensor will be able to measure both frequency and size of meteoroid punctures.

Data Processing

In this area, research was directed toward increasing reliability, efficiency, utility, and flexibility of the computer system. The Jet Propulsion Laboratory initiated a study to devise and apply "margin" test techniques for ground support equipment and spacecraft. Techniques of detecting the infrared emission from circuitry and the radio noise level will be utilized to obtain a new measure of reliability. Consequently, it will be possible to predict life and performance more accurately.

NASA Headquarters sponsored a study of a new type of computer memory using materials in which mechanical stresses and magnetic behavior are interdependent. An experimental device employing a combination of sound waves and electrical pulses moving along a small nickel-iron tube was successfully tested. The pulses created rings of magnetization spaced along the tube, and these magnetic areas constituted the stored information. The device offers the potential of economical high-speed random access without the mechanical problems of conventional disc and drum systems.

Work on logical or amplifying systems employing a liquid or a gas as the working substance (fluid systems) continued at Marshall Space Flight Center, and possible applications were being investigated. One—the "space lifeboat," a small emergency glide reentry vehicle—would be guided solely by a simple apparatus incorporating a "fluid" computer and other fluid components. The entire vehicle would be rugged, reliable, capable of rapid activation, and easy to use.

Progress was made in improving "hybrid" computers which use both digital and analog circuits. As a result of NASA sponsored university studies, operating speeds for these systems were increased and their power to solve complex engineering problems significantly enhanced.

In research on digital computer systems which use redundancy of parts to insure reliability, advances were made in methods of determining that all individual parts are functioning just before a launch. Overall testing of such redundant systems merely revealed that the system as a whole is functioning properly. Current progress in developing logical techniques will make it possible to check all parts without adding substantial numbers of extra wires or test terminals to the electronic apparatus under test.

Office of Emergency Planning Liaison

NASA also supported the National Resources and Evaluation Center of the Office of Emergency Planning with technical consultation and liaison on data processing for resources management and national emergency plans.

Aeronautics Research

Aircraft Operating Problems

The first flight tests in a general aviation aircraft handling qualities program were underway at the Flight Research Center. A Jet Star and an Aero Commander were tested; other late model aircraft, both single and twin-engine, representative of current production by different manufacturers, will be studied.

The primary objective of this research program is to formulate updated handling qualities criteria, emphasizing particularly rough air instrument flight operations with general aviation aircraft. The program calls for evaluation of all handling qualities; special attention will be given to those found to be problems.

Aerodynamics

In this field, research was conducted on boundary layer control, heating at supersonic speeds, and on fuselage shapes for hypersonic cruise aircraft. Wind tunnel tests were made to determine whether drag could be reduced and, hence, aerodynamic efficiency improved by blowing air for boundary layer control on thick wings. The tests were performed in NASA's 300 m.p.h. wind tunnel on a two dimensional wing; the air was blown from a single slot at 65 percent of the chord. Initial results were favorable and indicate that improvements of about 20 percent in section lift-to-drag ratio can be achieved on an airplane with boundary layer control. Further tests were planned on a wing of finite span.

The heat generated by an aircraft traveling through the atmosphere at high speeds for long periods may exceed the thermal limitations of components of the aircraft. Aerodynamic heating in the vicinity of surface junctures is one practical problem of this type, and no suitable theory for predicting heating rates in such regions was available. To obtain data on this problem for design purposes, systematic wind tunnel experiments were conducted. One such experiment, carried out at high supersonic speeds, investigated the effect of sweep on the heating rate. A rectangular fin, mounted on a flat plate was swept back in increments. Upstream of the fin, the heating rate decreased with increasing sweep angle.

Other research on externally contoured bodies of high fineness ratio may have application in large volume fuselages for hypersonic cruise aircraft capable of horizontal takeoff and landing. Low subsonic speed tests were initiated to determine how aerodynamic characteristics were affected by changing the body cross section from circular to elliptic. It was found that the oval body of increasing flatness is progressively more efficient in producing lift than the circular body. Minimum drag coefficients remained essentially constant over the entire horizontal-axis vertical-axis range tested, and the maximum lift-to-drag ratio increased continuously for increasing horizontal-axis vertical-axis ratio.

Aircraft Structures

The structural program continued research on problems associated with heating of the stainless steel or titanium alloys which may be used in the supersonic transport. Data was sought on the fatigue and other properties of these materials, and a particular effort was made to establish any degradation in these properties from long exposure to heating. The effect of thermal stresses and buckling on the flutter of skin panels in a supersonic airstream was studied. The purpose of this research was to better define, by means of more precise experimental measurements and improved theoretical approaches, the effects of the many aerodynamic and structural parameters related to the panel-flutter problem.

Investigations of refractory materials such as columbium and molybdenum for structural use in hypersonic aircraft moved forward with the initiation of a program which will use heat-resistant materials for the construction of sizeable structural test specimens embodying new concepts.

Air-Breathing Propulsion

A long-range comprehensive program of propulsion research for supersonic transport applications was initiated to improve inlet and exhaust nozzle performance, specific fuel consumption, engine component efficiency, engine weights, durability, and safety. Initially, a large part of the work will be contracted out to industry, but a substantial inhouse effort will be undertaken by the Lewis Research Center in order to utilize the experience of its staff and to increase its competence to direct and monitor the contracted programs.

A program was initiated to design, develop, and build an experimental hypersonic hydrogen-fueled ramjet engine that will operate with supersonic combustion. The engine will be investigated initially in ground test facilities and ultimately will be flown on the X–15 airplane at speeds from Mach 3 to 8. The program is divided into three distinct phases: Preliminary design, development, and flight testing. Preliminary design and development will be contracted out to industry; the flight testing will be conducted by the NASA Flight Research Center.

Supersonic Transport

NASA continued its research on methods of uprating the capabilities of the various design concepts for the Supersonic Commercial Air Transport (SCAT—the name given to a number of NASA developed shapes or design proposals). This research led to aerodynamic refinements and consequent major improvements in the performance of the basic supersonic transport configurations. (Fig. 4–4.) These refinements, applied to the wing design of the SCAT 15 concept, indicated much better flight characteristics at supersonic speeds and more than 15 percent increase in range; the potential gains were verified by wind tunnel tests.

SCAT 15 was one of four designs originally considered for possible development but laid aside about mid-1963 in favor of the SCAT 16 (fig. 4–5) variable-sweep and the SCAT 17 (fig. 4–6) delta-wing design concepts. However, research completed during this period indicated that the SCAT 15F, as the new version is known, is superior to the SCAT 16 and 17. Further research on the latter versions is expected to improve their capabilities also.

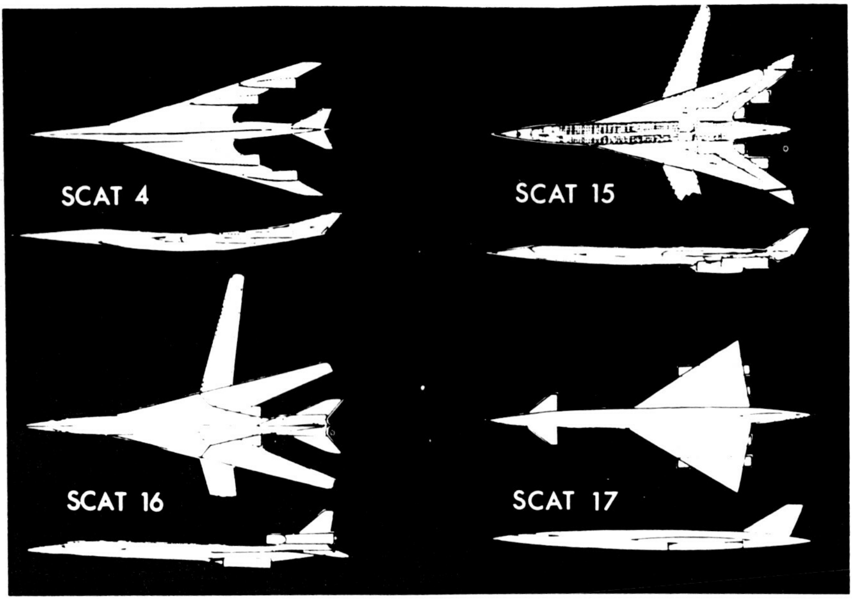


Figure 4–4. Promising SST design concepts.

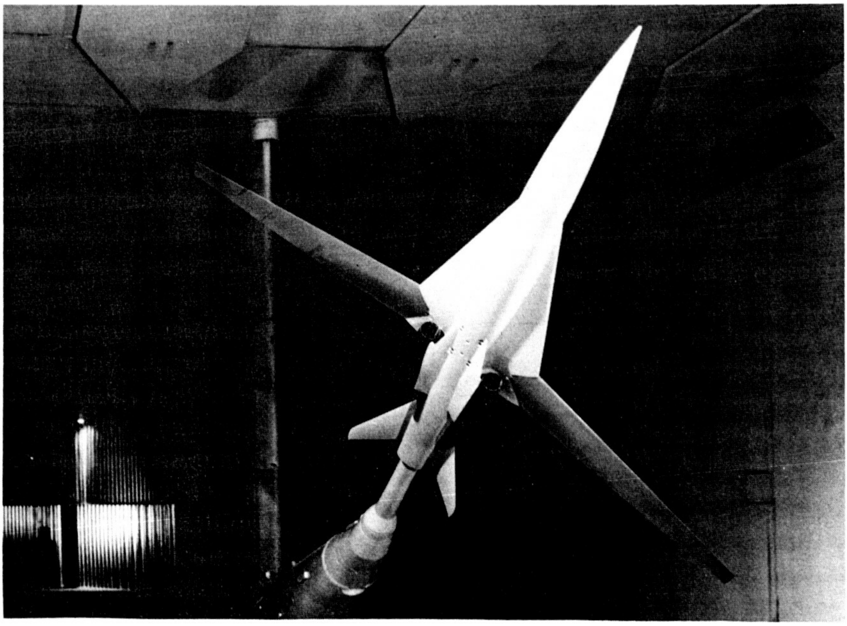


Figure 4–5. SCAT 16 model, wing fully extended, in wind tunnel.

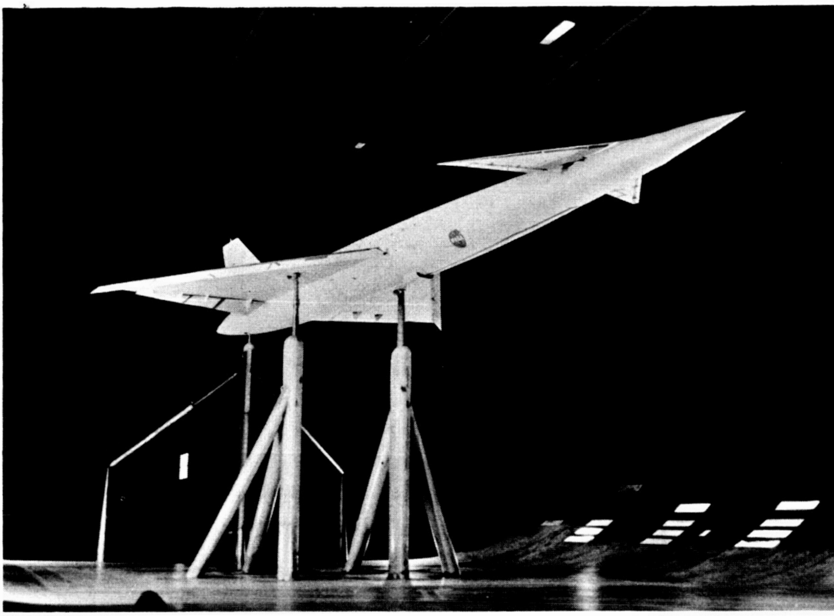


Figure 4–6. SCAT 17 model being prepared for wind tunnel tests.

SCAT 15F (fig. 4–7) has a larger wing area than the original SCAT 15 design, fixed sweep, and improvements in camber and twist. The fuselage is long and slender, and engine nacelles are positioned so as to give the most favorable interference effects. An SST design based on this new concept should meet the minimum performance requirements set forth in the Federal Aviation Agency's August 1963 RFP for bids on the design and development of a commercial supersonic transport aircraft.

The research information embodied in the SCAT series was made available to industry, military, and other Government agencies and studied intensively as a part of the national supersonic transport prototype development program managed by the Federal Aviation Agency.

Hypersonic Aircraft

A performance and weight trade off study was made to define the mission capability of large volume hypersonic transports (fig. 4–8) propelled by hydrogen-fueled turboramjets in the Mach 4 to 8 range. The results showed that this type of aircraft will be capable of sustained flight to ranges approaching one-half the earth's circumference. At ranges in the neighborhood of 5,700 to 6,800 miles, 20 to 25 percent of the gross takeoff weight will be available for payload and fuel re-serves. This excellent performance was based on the use of hydrogen fuel. However, the studies also indicated that the maximum desirable cruise speed may be dictated by cooling requirements of the inlet and engine.

Several specific areas for additional research and study were indicated: Inlet and engine cooling, landing problems for aircraft with very long fuselages, and high-speed stability characteristics for aircraft with large fuselages. Further work on configurational studies, engine and exhaust nozzle development, and structural tankage problems will also be required before the indicated payload levels and trends can be confirmed.

X–15 Research Airplane Program

Two of the three X–15 research airplanes continued flight tests during the greater part of this period, providing additional information for the optical degradation, heat transfer, boundary-layer noise, and skin-friction experiments. The third airplane was being modified during most of the period to increase its capability to Mach 8, from the present maximum of Mach 6.06.

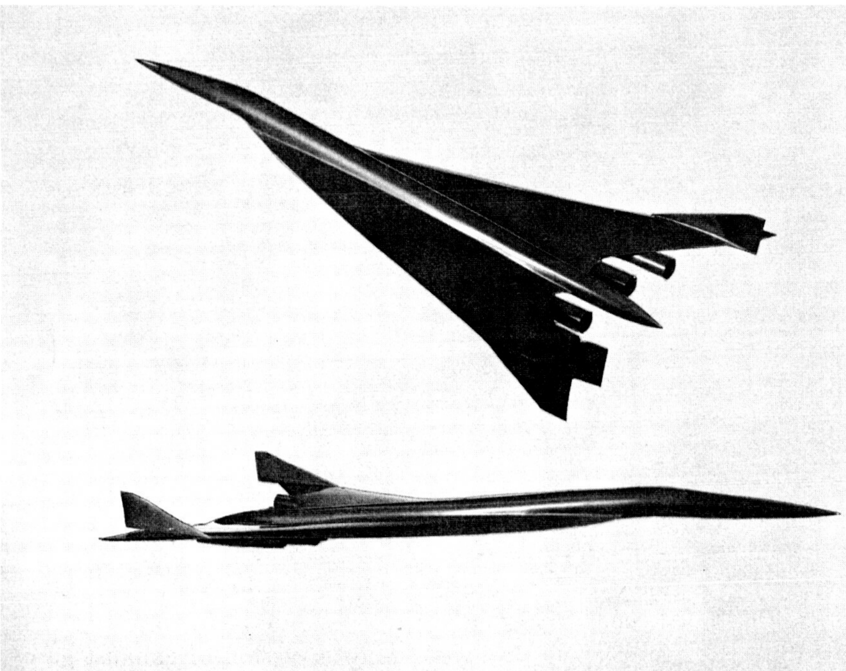


Figure 4–7. Two views of SCAT 15F model.

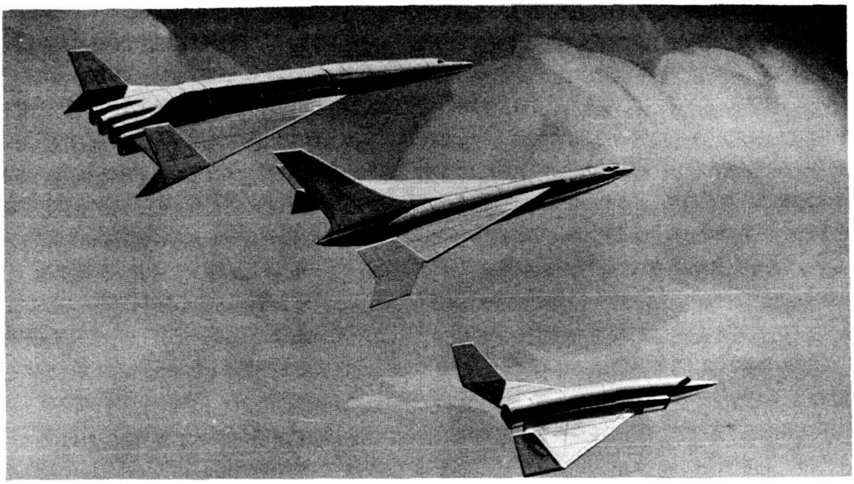


Figure 4–8. Possible hypersonic aircraft configurations.

In the first 6 months of 1964, the 3 airplanes made a total of 13 flights, two more than during the corresponding period last year. As of the end of June 1964, the three X–15 airplanes had made a total of 110 flights; the 100th flight was made on January 28.

The X–15–2, (fig. 4–9) modified for Mach 8 flight, was rolled out of the contractor's plant on February 14, 1964, following a 9-month rebuilding and modification program. Modifications included two external propellant tanks, improved windshield configuration, landing gear, and research instrumentation. The first flight took place on June 25.

Vertical and Short Takeoff and Landing (V/STOL) Aircraft

Previous theoretical and wind tunnel investigations indicated the feasibility of using the lifting fan concept for a functional V/STOL aircraft. To obtain additional research information on the concept, a full scale fan-in-wing model having geometric characteristics closely approximating those of the Army's developmental XV–5A aircraft (fig. 4–10) was tested in the 40- by 80-foot tunnel of the Ames Research Center. Fan performance, general low-speed aerodynamic, stability, and control characteristics were obtained in and out of ground effect. The results indicated that an airplane of this design should have static stability and be controllable throughout the transition speed range. In some landing conditions, the proximity of the ground caused an adverse effect on fan lift due to ingestion of exhaust gases into the inlets; it was found possible to eliminate this effect by changing the setting of the tip-turbine exhaust gas louvers, thus vectoring the gases away from the inlets.

Figure 4–9. Modified X–15–2 showing fuel tanks and new windshield.

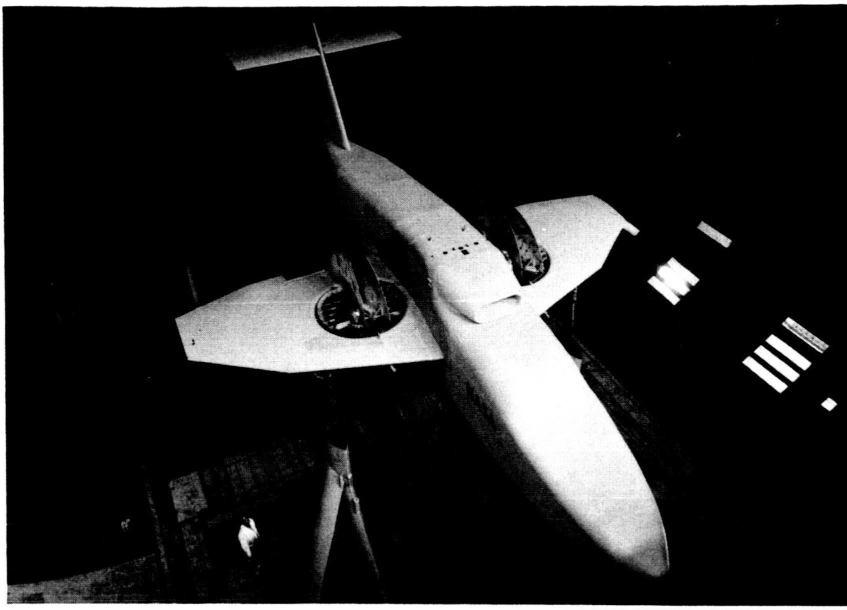


Figure 4–10. Fan-in-wing model based on the XV–5A design.

The static lateral and directional control characteristics of a one-fifth scale, two-propeller deflected-slipstream STOL airplane, typical of the COIN (counter-insurgency) airplane, were investigated in the 17-foot tunnel test section of the Langley 300-m.p.h. tunnel at very low speeds (fig. 4–11). The aircraft was a general research model with three different tail arrangements: An **H**-tail and a **T**-tail on a center fuselage extension, and an inverted **V**-tail on twin booms. The wing was equipped with double slotted flaps and utilized a slot lip aileron (spoiler), differential deflection of the rear flap element as a lateral control, or differential propeller thrust (differential propeller pitch) for lateral and directional control. The wing was unswept and was tested with spans of 5 and 7 feet.

The results indicated that with proper tail size the airplane would have adequate longitudinal trim and control power down to very low speeds. The lateral control effectiveness of the spoiler for the two wing spans with different flap settings was found to be adequate, even for the engine out case, with very little yaw due to spoiler projection. The lateral-directional-control characteristics of the flap were found to be adequate when it was used in conjunction with differential propeller thrust. The large yaw due to roll and the relative low-roll effectiveness of the differentially deflected flap made it necessary to couple this control with the propeller pitch control to provide a good lateral-directional-control system.

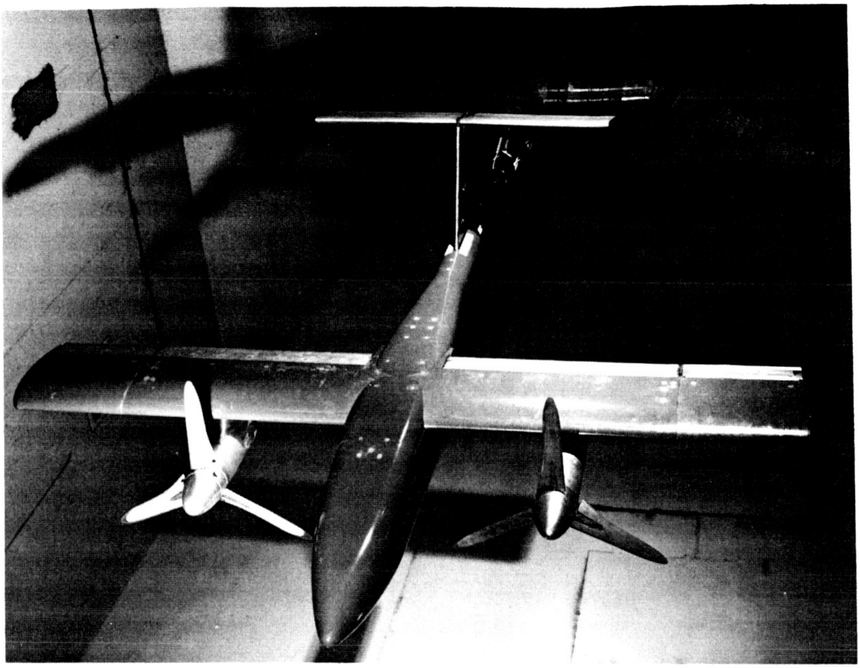


Figure 4–11. COIN model in Langley 17-foot test section.

In May, flight tests were completed on the VZ–2 tilt-wing flying "test-bed" at the Langley Research Center. Since 1960, when work began on this project, extensive information has been obtained on performance and handling qualities in hover, transition, forward flight, steep climbs, and descents. The results, especially recent data on the effects of full-span flaps and wing leading-edge droop in retarding wing stall during transition, should aid in the development of more advanced tilt-wing V/STOL aircraft. The VZ–2 also served as a V/STOL flight-training aid: Pilots of the two current tilt-wing developmental aircraft—the XC–142A (fig. 4–12), on which extensive wind tunnel tests have been made, and the CL–84—requested and made indoctrination flights on the aircraft.

Ground-based simulator studies were previously undertaken at Ames to aid in defining low-speed handling qualities criteria for STOL transport aircraft. These simulator studies were validated with the C–130B boundary layer control STOL aircraft, equipped with variable stability and control equipment. Initial flight tests with this aircraft in the landing approach confirmed the simulator prediction that the inclusion of appropriate damping would greatly reduce sideslip excursions of the aircraft and thereby improve pilot opinion of the low-speed maneuvering characteristics. Simulation studies of the

Breguet 941 STOL aircraft indicated that similar augmentation of its basic stability characteristics would result in satisfactory lateral-directional handling qualities at landing-approach speeds down to 45 knots.

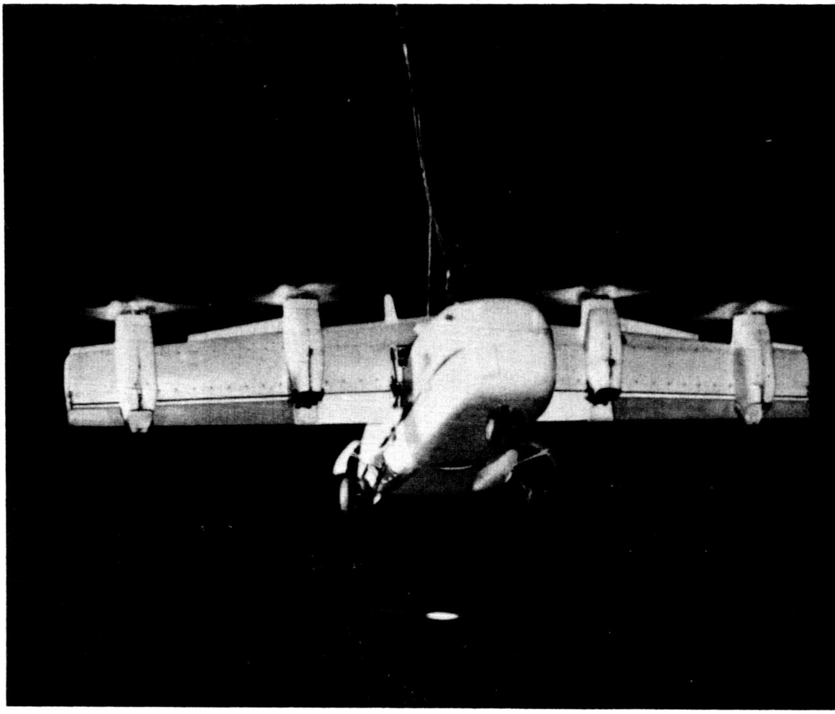


Figure 4–12. XC–142A model in free-flight wind tunnel test.

Biotechnology and Human Research

The Interagency Life Sciences Supporting Space Research and Technology Exchange (ILSE) (discussed in NASA's *10th Semiannual Report*, p. 125) was extended to include proposed NASA and Department of Defense (DOD) fiscal year 1965 life sciences research tasks. Under ILSE, over 200 subgroups of research abstracts reporting individual research were tabulated, and 7 program review groups composed of Air Force, Army, Navy, and NASA technical personnel were formed. The program review groups were reviewing each package of abstracts for accuracy, for agency interest, and for duplication of effort. Printed material relating to each of the 200 subgroups was being prepared for submission to the individual laboratory researcher.

Effort during this period was directed to developing the ILSE system with the objective of putting it into operation early in the

1965 fiscal year. It could then be used to balance and coordinate NASA and DOD research programs for that year.

Life Support and Protective Systems

Life Support and Protective Systems Research has two major objectives:

To accumulate and validate biotechnology data which can be used in the design of manned spacecraft and manned extravehicular systems.

To develop life support equipment which can satisfy human requirements during space flights lasting from 1 hour to 3 years.

Life Support Systems.—The feasibility of developing complete life support systems with specific weights of less than 10 pounds per man per day for missions exceeding 1 year was demonstrated in April when a 30-day test of an integrated five-man life support system was completed. The work was done under contract.

Another partially regenerative system suitable for multiman operations for up to 1 year and capable of recovering both oxygen and water but not food was being developed for NASA. The contract, monitored by the Langley Research Center, calls for delivery of a prototype four-man system in February 1965.

Work was well underway on advanced multimanned systems applicable to missions lasting up to 3 years. The objective of this research is to completely close off all subsystems and reclaim all metabolic wastes. Project RAW (Recovery of Air and Water) at the Manned Spacecraft Center was developing techniques for processing all metabolic wastes to recover oxygen and water; food regeneration studies were planned.

Bioinstrumentation.—The major effort in bioinstrumentation was the development of PIAPACS, Psychophysiological Information Acquisition Processing and Control System—a closed loop man-machine control system. It will be able to predict the psychophysiological state of the subjects, establish and provide required control signals for performing adjustments in environmental control and flight control systems, and provide outputs to derive the display subsystems. Major subsystems will include the sensor subsystem, the undergarment subsystem, the signal transfer subsystem, the computer subsystem, and a display and control subsystem.

For the sensor subsystem, a flight type mass spectrometer weighing less than 35 pounds was developed. It can make a breath-by-breath analysis of inhaled and exhaled respiratory gases, at the same time sense the composition of gases in the compartment and astronaut pilot suit, and monitor continuously in flight the presence of gases with mass numbers through 50. Flight testing was scheduled for the latter part of 1964.

Surgically implantable bioinstrumentation to obtain critical physiological information from experimental animals was developed. Several of the instruments have already demonstrated their value in human surgery. For example, the automatic perfusion pressure regulator—a hydraulic servosystem—nourishes the coronary arteries with blood and enhances safety during open-heart surgery. The prototype implantable oximeter will also be valuable in open-heart surgery. It measures oxygen carried by the blood to the principal arteries and veins under stress and can monitor the performance of artificial lungs of heart-lung machines. And the interarterial manometer—a device to measure blood pressure continuously—is being widely used during major surgical operations of all kinds. (Fig. 4–13.)

Displays and Controls.—Among instruments to simplify man's task in controlling spacecraft equipment and in conducting extraterrestrial exploration and operations was a contact analog display device now being fabricated for use in a manned aerospace flight simulator. It produces a visual display and unambiguous visual cues for the pilot. A voice input control system to accept commands during manned operations outside the spacecraft was being developed under contract.

Locomotion and Protective Systems.—Work in this task area included a number of projects investigating techniques and devices to protect man in both the restrained and locomoted modes. One study of the requirements for manned locomotion and protection during extravehicular operations on the lunar and Martian surfaces was completed; another project investigated the possibilities of adapting existing suits to the demands of extravehicular use and of developing new concepts; in another effort, a nonanthropometric hard suit was being developed (fig. 4–14); and the design of a passive suit for lunar exploration was being studied (fig. 4–15).

Figure 4–13. (L to R) Automatic perfusion pressure regulator, implantable oximeter, and interarterial manometer.

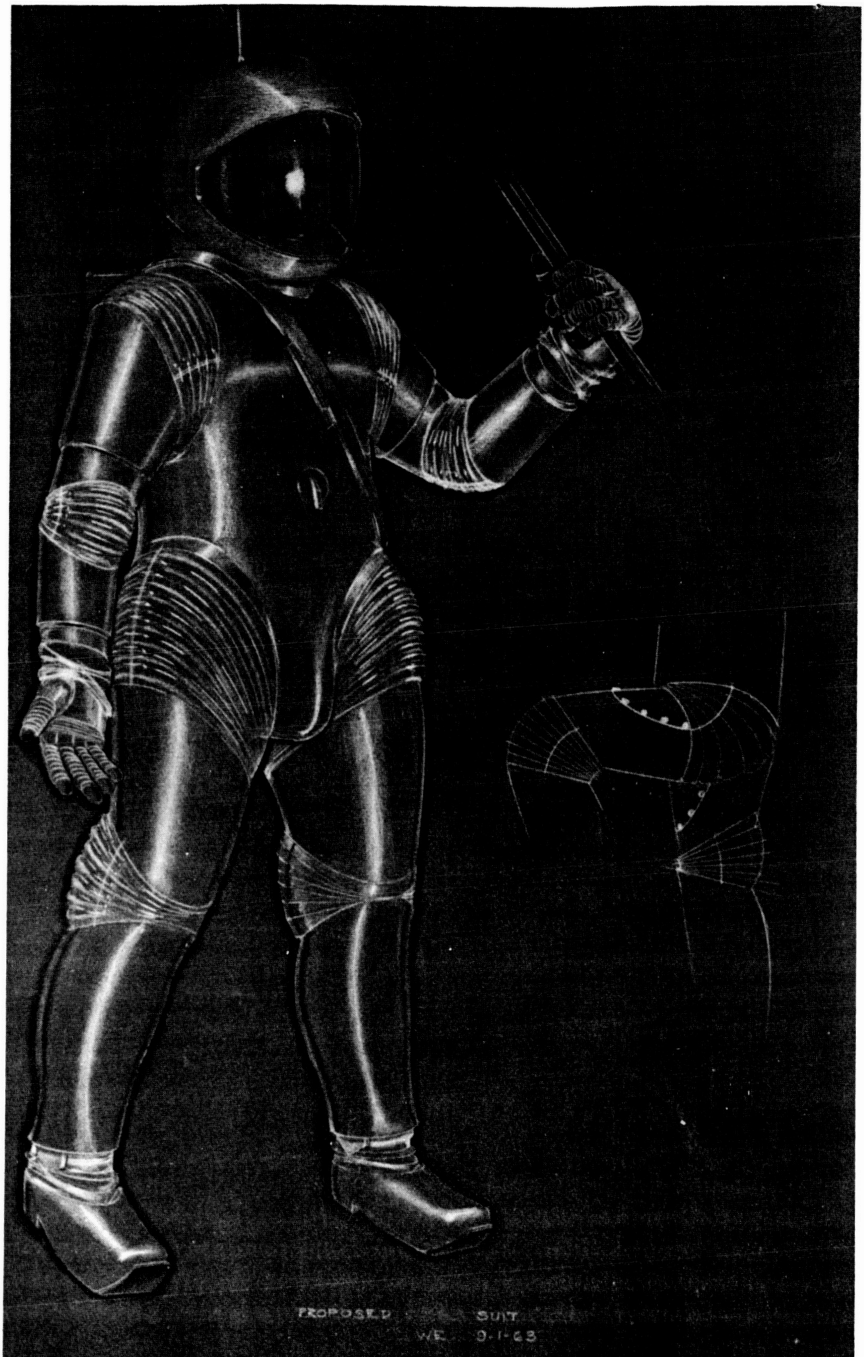


Figure 4–14. The hard suit.

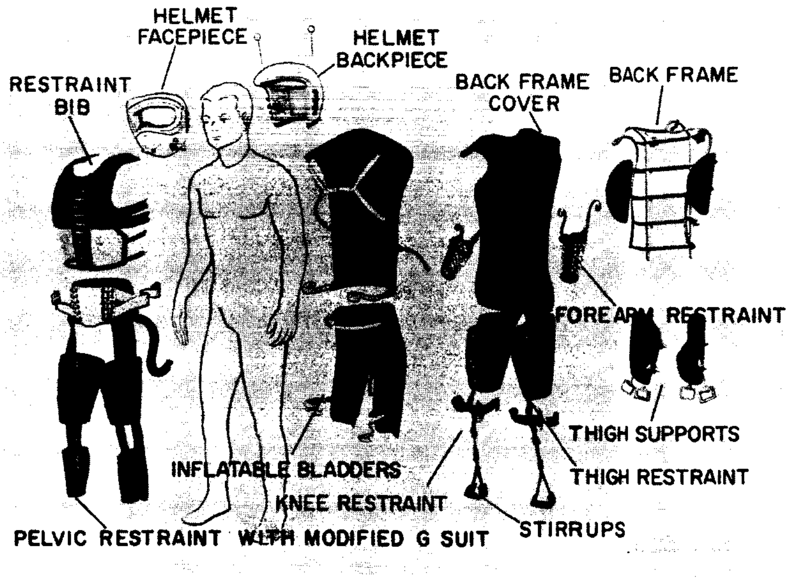


Figure 4–15. Elements of the passive (mobile restraint) suit.

In other related work, an airbag restraint system was studied. In April, the prototype system was tested with an articulated dummy in conjunction with the FAA air crash test program.

Human Research

Recent studies of the vestibular system reliably linked certain psychophysiological measurements with susceptibility to motion sickness. This information makes it possible, for the first time, to preselect personnel likely to become sick or incapacitated from exposure to unusual or moderately excessive vestibular stimulation.

Additional research on the biological effects of magnetic fields reconfirmed earlier conclusions that man is apparently not dependent on the presence of the normal magnetic field forces of the earth. However, analysis of the most recent data also indicated that the visual responses of an individual were adversely affected in one respect. In the flicker-fusion rate test, test subjects saw the flickering light as a single light when it flickered at a rate of 10 flashes per second; a normal subject sees the flickering light as a single light at a rate of 16–20 flashes per second.

Studies of the effects of oxygen concentrations on vision at various atmospheric pressures caused a tentative reevaluation of standard rules

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for oxygen usage by pilots. As a result, the practice of using pure oxygen at night from the time of takeoff will probably be stopped, and the rule requiring oxygen masks at 10,000 feet may be changed to 13,000 feet.

Radiobiology programs to determine the biological effects of radiation particles of the types encountered in space, particularly protons, were underway in a number of laboratories. At the University of California, Berkeley, modifications to the experimental radiation facilities were completed. Research continued on whole-body radiation of primates in order to study the relative sensitivity of different organ systems, such as bone marrow, intestinal epithelium, and skin. By establishing responses with monoenergetic beams, investigators can then study the response of primates to mixed energies simulating solar flare spectra. Other research was being conducted on radiation effects on mammalian cells in vitro, on the effects of heavy ions on unicellular organisms, and on the protective effects of magnetic fields. At the Oak Ridge National Laboratory, theoretical studies were completed on the penetration of protons in tissue slabs for energies between 50 and 400 million electron volts (Mev.).

Research was completed on establishing the relative biological effects (RBE) of protons in the energy range from 22 to 730 Mev. on bacteria. In this work the biological end points used to determine the RBE of protons were cell inactivation and mutation. The RBE for proton effects in this experiment was equivalent to that produced by X- or gamma rays; therefore, the RBE is unity or one. A study was initiated at Harvard University on the effect of low dosage, long-term proton radiation on the bodily defense against bacterial invasion. Preliminary results seemed to indicate that a specific dose of radiation given over a long period at a low-dose rate was more damaging than a similar total dose given acutely.

Man-System Integration

A study was completed on the performance of a group of five persons during a 30-day period of confinement; this work was part of a larger study on the development and test of a 150 man-day life support system. In general, it was found that confinement itself did not appear to be particularly stressful for the crew, that there was no dropoff in performance, and that the crewmembers demonstrated no unusual or abnormal reactions, such as hallucinations. However, there was evidence of considerable irritability and hostility with a parallel drop in positive mood. Some visual changes did occur, with an increasing exophoria (outward deviation of the eyes from the visual axis) during the test. This effect disappeared shortly after the individual left the chamber.

The effect of vibration on the ability of pilots to control a high-thrust booster vehicle was studied. It was found that the pilot's ability to control the vehicle deteriorated rapidly at the higher levels of vibration, but that acceleration was not a critical factor in the range tested. The most important factor was the loss of visual perception of the instrument displays.

In a study to determine the effects of one-sixth earth gravity on the ability of astronauts to walk, jump, and climb, lunar gravity was simulated by means of a canted walkway inclined 9.5 degrees from the vertical, with the subject appropriately supported by cables at various parts of the body (fig. 4-16). These locomotion activities were compared for earth and lunar environments by using a split-screen technique.

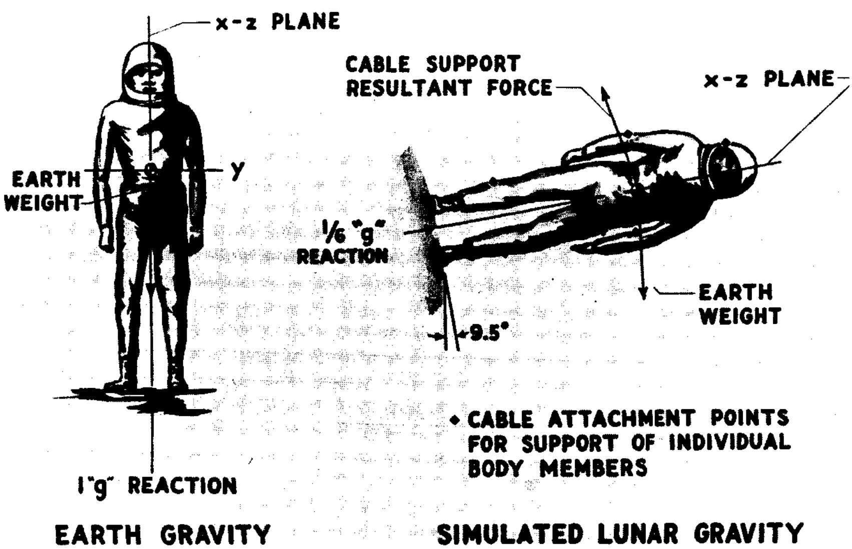


Figure 4-16. Lunar gravity simulation.

Chemical Propulsion Systems

Solid Propulsion Technology

The solid propulsion research and technology program seeks to develop flexible, reliable propulsion systems with the capability for maximum performance. During this period, research continued on the expandable space nozzle (successfully tested for 60 seconds), the cap pistol system, and the subliming solid control rocket. In addition, nozzle materials were evaluated for ability to withstand the effects of combustion, combustion oscillations and instability were investigated, stop-restart capabilities for solid systems were studied, and work progressed on detecting propellant voids and determining critical void size.

Large Solid Propellant Motor Program

After a 3-year detailed study of the possible use of solid propellant motors in the space program, it was concluded that the potential advantages of solid propulsion were sufficient to justify a major investigation. Accordingly, NASA and the Department of Defense concluded an agreement under which the Air Force funded and provided for technical direction of technology programs on large solid motors starting in fiscal year 1962 and extending through fiscal year 1964. Starting in fiscal year 1965, NASA agreed to provide support for the work on the high-thrust, 260-inch diameter class of motors.

The current program involves the manufacture and static test firing of four 260-inch diameter solid fuel motors delivering over 3 million pounds of thrust for 2 minutes. These motors will be 70 feet long and weigh almost 2 million pounds. The planned follow-on program calls for building and testing two motors of the same diameter, but twice as long, with thrust levels of over 6 million pounds. They represent more than a fourfold increase in thrust level over the F–1 engine, and are designed with generous reserve capacity so that they may be lengthened by about 25 percent to give a thrust level as great as 10 million pounds per motor.

During the period of this report, each of the two contractors responsible for this part of the program completed new waterside large motor manufacturing facilities built expressly for processing 260-inch diameter motors at an estimated cost of over $10 million. Subcontracts were let for chamber fabrication, nozzles, insulation, and other components, smaller subscale motors were fired for component evaluation, and each contractor scheduled two static tests to be conducted by mid-1965.

Silo-type pits about 50 feet in diameter and over 120 feet deep will be used to load and fire the motors; their size will enable them to accommodate the larger motors contemplated later. The motor cases, made of a recently developed nickel-steel alloy, will be transported by barge from the shipyards where they are made, installed vertically in the pits, nozzle end up, and prepared for the casting of propellant. The propellant, similar to one used in the Minutemen program, will then be mixed, transported to the case, and poured into place. Over 1½ million pounds of fuel will be used in each motor, requiring several weeks of continuous pouring. When the propellant has cured and hardened, the motor will be prepared for firing, the nozzle attached, and the test performed.

To determine the best potential applications for these motors in large space boosters, one of several projects investigated the combination of a single 260-inch diameter motor with the S–IV B hydrogen-oxygen fuel stage now planned for Saturn vehicles. This combination, which could place more than 50,000 pounds of payload in orbit, offers the simplicity of a two-motor vehicle and the possibility of remarkable reliability with little testing.

Supporting research and development, contracts were made with industry and other Government agencies to investigate stage and motor subsystems, components, and materials. Examples: development of motor failure warning systems to give the astronauts time to escape safely; studies of fabrication and inspection methods for the unusual nickel alloy steel used in large motor cases; analyses of the stresses in huge propellant charges during production and use of the motors; and reliability analyses of motors, their components, and clustered stages.

Liquid Propulsion Experimental Program

The objective of this program is to continue the advancement of promising propulsion system concepts until the feasibility of experimental systems can be demonstrated on as near an operational basis as is practical. The experimental program encompasses propulsion systems ranging from engines developing only a few pounds thrust to the M–1 liquid oxygen-liquid hydrogen engine of the 1.5-million pound thrust class. It also includes significant effort in the fluorinated oxidizer high energy propellant area to demonstrate the increased performance promised by these advanced systems as well as the storage and handling of high energy propellants under near operational conditions.

In January, the M–1 engine program was officially transferred from the Office of Manned Space Flight to the Office of Advanced Research and Technology as part of the liquid propulsion experimental program. The program progressed through construction of facilities and engine hardware fabrication and began initial testing of engine components. Facilities for component testing neared completion and emphasis was placed on completing engine test stands that will permit full duration firing of the complete engine system. In component testing, the gas generator which provides power to the turbine for pumping the liquid oxygen-liquid hydrogen propellants was tested, seal model tests of fuel pump hardware were initiated, and tube bundles for two of the tube wall chambers were fabricated.

The fluorinated oxidizer program advanced in two areas of research. Preparations were made to demonstrate that the Pratt and Whitney 15,000-pound-thrust RL–10 liquid oxygen-liquid hydrogen engine can operate satisfactorily on the liquid fluorine-liquid hydrogen propellant combination with only minimum changes to ensure compatibility with the highly reactive fluorine. The other research effort was initiated to investigate the feasibility of employing mixtures of liquid oxygen and liquid fluorine as the oxidizer with fuels of the light petroleum gas family, which can be liquified at temperatures approaching that of the cryogenic oxidizer mixture. Such an arrangement would minimize propellant storability problems during the long periods of exposure to the space environment which will occur on future missions currently under study.

To avoid development problems in auxiliary propulsion systems for attitude control and maneuvering in space, efforts were initiated to design a universal 100-pound-thrust auxiliary engine which would not be affected by the operational duty cycle or by installation (whether mounted inside or outside the vehicle). Knowledge gained from the Gemini and Apollo development program on the effects of the duty cycle and installation parameters on the auxiliary engine design was applied to this research.

Liquid Propulsion Systems

One of the problems associated with launch vehicle propulsion research is the increase of chamber pressure to approximately 2,000–2,500 p.s.i. or 2–4 times present operating levels. During this period, steps were taken to prepare the technology for these new operating conditions, with particular emphasis on developing the ability to pump propellants to pressures as high as 5,000 p.s.i. to compensate for pressure losses in the engine cooling system and injectors. Work was also done on stress levels, materials, fluid flow rates, bearings, and seals as well as on determining the proper size and number of pumps to be used. In the latter effort, system variables such as pump acceleration, lag or overspeed of one or more pumps, the effect of mismatched pumps, and valve sequencing effects on the pump and gas generator were investigated. In addition, as a means of producing better pumps, work progressed on the impulse pump stage, hydrostatic bearings and seals, flowin pump passages at high flow inlet angles, and cavitation phenomena in the candidate cryogenic propellants.

Thrust augmentation, a method of improving the operation of rocket engines by deriving air from the atmosphere during the atmospheric portion of flight, was investigated. It could increase efficiency and also reduce the quantity of propellant that must be carried. Studies showed that this type of thrust augmentation will work in a limited portion of a typical booster trajectory but that more than a simple addition to the vehicle will be required. The equipment must have a high degree of geometric variation in both inlet and exhaust sections in order to match variations in speed and air density as the vehicle moves along. Also, any augmentation that can be achieved will be small. These studies eliminated the simple augmentation system from consideration but tended to confirm the value of continued effort on composite cycle engines.

Research efforts on high energy liquid hydrogen for spacecraft applications were directed toward solving the problems associated with space storage of this fuel. One method of mitigating this problem—gelling the hydrogen—was reported in NASA's *10th Semiannual Report.* Although studies in this period did not fully establish the characteristics of this gell, they did show that the evaporation rate was reduced about ⅓ to ½ that of liquid hydrogen, that the sloshing and zero gravity problems were likely to be alleviated—all at a small performance penalty.

Another method of solving the problem is to evolve propellant combinations that are inherently space storable. Research on oxygen difluoride/diborane, which is in this category, progressed significantly, and simulated altitude tests were planned to determine the high expansion ratio performance characteristics.

A sophisticated analysis of the real flow in nozzles, including chemical kinetic and nonequilibrium thermodynamic effects, was made and a computer program prepared and delivered to the Lewis Research Center. It can be used to predict the performance of any propellant.

Several research projects on ablative thrust chambers were initiated to obtain a fuller understanding of the ablation process as a basis for building thrust chambers and nozzles better able to withstand the high combustion temperatures of space storable propellants. The projects include an analysis of the mechanism of ablation covering such factors as heat loads, gas composition, velocity effects, and ablator composition. Improved resins and fiber materials were being sought for use in ablative engines.

Basic Research

Fluid Physics

Entry Heat Transfer Research.—Studies were undertaken to determine the heat transfer conditions in carbon dioxide-nitrogen (CO_2-N_2) mixtures in connection with research on hypersonic entry into Martian and Venusian atmospheres. Total radiation measurements were made in shock tubes and ballistic ranges as a function of velocity for mixtures of 9 percent CO_2 in N_2. At speeds below 31,000 feet per second (f.p.s.) the total radiation was found to exceed the radiation from air by factors of 10 to 100 because of the strong contribution of cyanogen. Above 31,000 f.p.s., however, it was found that the molecular components of the gas are dissociated and the radiation is mainly from ion-electron reactions which produce very nearly the same radiation as air does at comparable speeds. Shock tube tests also showed convective heat transfer to be about the same in a CO_2-N_2 mixture as it is in air for speeds up to 45,000 f.p.s.

Magnetohydrodynamic Reentry Simulator.—A prototype hypervelocity wind tunnel for reentry simulation achieved velocities and densities characteristic of orbital atmospheric reentry for the first time. The 1 x 1 inch cross section electromagnetic plasma accelerator at the Langley Research Center was operated for several seconds at an exit velocity of 20,000 f.p.s. and at a density equivalent to 150,000 feet altitude. The test gas was nitrogen, the main constituent of the earth's atmosphere. A followup accelerator model was planned; it will be 2 x 2 inches in cross section, expanding to a 5 x 5-inch test area. An exit velocity of 40,000 feet per second is anticipated at a density equivalent to 200,000 feet altitude. This range covers the velocities and densities for lunar or planetary reentry. Although the main characteristics of the reentry situation now appear to be reproducible, realistic tests cannot yet be conducted because the accelerator test gas is too hot. Developing ways of minimizing this heat will be a primary objective of planned research.

Applied Mathematics

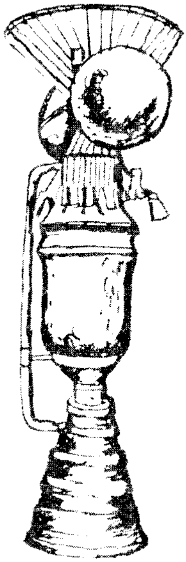
The Marshall Space Flight Center developed an improved procedure for numerical integration of differential equations by power series expansions. Mathematical and physical examples demonstrated that for some problems this procedure is superior to even the best interpolation methods, such as the Runge-Kutta-Fehlberg method, which has been accepted by mathematicians. The improved procedure was used to trace several paths of moon probes around the earth and moon and to compute the motion of an electron in the field of a magnetic dipole, such as the path of a charged particle from the sun entering the earth's polar atmosphere to cause an aurora borealis. In both cases, the differential equations of motion were solved numerically more quickly, more accurately, and more economically than by older methods.

Materials Research

Research in this area was focused on determining the fatigue properties of stainless steel and titanium alloys—the most promising materials for the commercial supersonic transport. In a series of investigations of these alloys, their fatigue strengths were not significantly affected by temperatures as high as 800° F., which is about 300° F. higher than a Mach 3 transport will experience. Equally important from a safety point of view, the rate of fatigue crack growth was lower and the remaining static strength after formation of a fatigue crack was higher in these alloys than in the aluminum alloys now used in commercial transports. Consequently, it appeared that fatigue will be no more troublesome in the supersonic transport than it has been in subsonic transports, and it may be significantly less. However, additional fatigue tests of the alloys were planned.

Electrophysics

A significant advance was achieved in the use of X-ray spectroscopy for investigating the atomic structure of matter in the 15–40 angstrom (A) wavelength region. Under a NASA grant, an investigator at New Mexico State University succeeded in growing some potassium acid phthalate (KAP) single crystals having the required spectrometric properties in the 15–25 A range. This research extends the use of X-ray spectrometry into a previously difficult region which now may be investigated for new information on the atomic structure of materials. Results of this research may also be extended to industry by using the successfully grown crystals as "seeds" to produce large KAP crystals for industrial research laboratories.



5 NUCLEAR PROPULSION AND POWER GENERATION

During the period, NASA continued with the established programs and projects that are expected to lead to development of the SNAP–8 system and establish the necessary technology for advanced systems. Also, the Agency continued its work in the nuclear electric power research and technology program, in the electric propulsion program, and in the nuclear rocket program.

The SNAP–8 Development Project

As indicated in the previous report (*10th Semiannual Report*), the joint NASA-AEC SNAP–8 project is expected to develop a 35 kw. nuclear electrical generating system capable of startup and continuous, unattended operation in space for 10,000 hours. (This is the largest electrical power system being developed by NASA.) Potential applications include power for a manned orbital space station, a lunar station, manned or unmanned space probes, communication satellites, and other future advanced programs.

Construction of a large number of experimental liquid metal test loops was continued and some were completed. Also, most of the experimental test hardware (turbines, alternator, seals, boiler, etc.) were fabricated.

Other accomplishments in the first half of 1964 included the following: In the seal-to-space development, low leakage of SNAP–8 fluids to a vacuum environment was demonstrated. The alternator passed the acceptance test. Testing was started on the integrated turbine-alternator assembly. The experimental reactor completed the 60-day power test at rated temperature (on April 28). Preparations for testing mercury power conversion loop components at rated conditions were nearing completion. And a number of corrosion loops for testing the reactor piping system were completed and put to test.

The Nuclear Electric Power Research and Technology Program

As pointed out in earlier semiannual reports (*9th* and *10th*), the nuclear electric power subprogram is expected to develop systems for propulsive and nonpropulsive auxiliary power for spacecraft. Multi-kilowatts of electrical power will be required for auxiliary or nonpropulsive power applications; multimegawatts of electrical power will be required for propulsion. The principal concepts being investigated for converting nuclear thermal energy to electrical energy are the Rankine cycle turbomachinery systems and thermionic direct conversion systems.

During the period, testing of a multitube condenser was completed in the Lewis radiator condenser facility. The tests confirmed earlier theories that the condensing heat transfer coefficients were about equal to those in the condenser tube walls and the liquid film on the all liquid side of a typical condenser. In another area of investigation, a centrifugal pump was run for 350 hours, pumping liquid potassium at 1,400° F. to study cavitation effects in a mixed flow impeller.

A Brayton cycle radial turbine was tested on cold air and demonstrated a total to static pressure efficiency of 84 percent (predicted efficiency was 82 percent).

During this period, investigation of journal bearing stability using water as a lubricant demonstrated that three bearing types are resistant to destructive half-frequency whirl. These three bearings are a tilting pad-type bearing, a three-lobe bearing, and a double axial groove bearing.

Out-of-pile life tests of thermionic converters were underway at two contractor facilities. One contractor's tungsten converter employing a molybdenum collector with an emitter temperature of 1,830° C. operated for 1,600 hours at a power output of 7.5 watts per square centimeter. The other contractor's UC-ZrC fueled tungsten emitter molybdenum collector converter, operating at 1,800° C., ran for 1,850 hours at 7.5 watts per square centimeter. Both tests were continuing. The second contractor worked out improved processes for fabricating relatively ductile tungsten emitters, and achieved the experimental verification of a number of thermionic fuel parameters (burnup, swelling, fission gas release, fuel vaporization, etc.).

The Electric Propulsion (Electric Rocket Engine) Program

As mentioned previously (NASA *10th Semiannual Report*), the electric propulsion program is expected to provide the research data and technology for the development of both low- and high-power engines; develop, test, and evaluate laboratory engine models; and investigate advanced concepts of electric propulsion. The program involves research in three basic types of engine systems—electrostatic, electrothermal, and electromagnetic. The work ranges from basic studies to the demonstration of engine systems in laboratory facilities and, as necessary, in the actual space environment.

Electromagnetic Engine Research and Technology

In the electrostatic engine field, two systems were receiving major attention during the period: The surface contact ion engine and the electron bombardment ion engine. A contractor completed a small (less than 0.5 kw.) cesium contact ion engine system for stationkeeping and attitude control application. Laboratory evaluation of this system was underway to ascertain its performance and the areas requiring further research.

With the large engine systems for prime propulsion, research was proceeding on complete engines and their associated problem areas in the 3 kw. to 30 kw. range. This research continued to be directed toward determining performance capability, durability, and scaling effects prior to proceeding to the megawatt range.

In another effort, a contractor was to fabricate a 3 kw. linear-strip cesium contact ion engine that could be clustered into larger sizes. Under still another contract, a 3 kw. cesium electron bombardment engine was fabricated and tested. This engine was undergoing further tests at the NASA Lewis Research Center. Also at Lewis, other tests were proceeding on a 30 kw. single module mercury electron-bombardment engine to determine the effects of scaling from the 3 kw. size (fig. 5–1).

A supporting research program on the problem areas associated with all of these engines was continued. This research is expected to provide additional data on means of generating ions (ionization), means of accelerating ions, the electrical theory relating to the effects of building up a space charge, and the composition and behavior of ion beams. The applied technology areas associated with this research include the factors influencing fabrication of porous metal ion emitters, design considerations of electrical circuitry and components, design of propellant feed and storage components, and selection of various materials.

As an illustration of the kind of problems being investigated, one of the limiting factors in the life of the contact ion engine is the ion emitter. If all the cesium propellant is not ionized, the neutral particles remaining can cause erosion of the electrodes. Studies during the period showed that ionizers made of spherical tungsten particles and doped with 10 percent tantalum may provide an excellent ionizer with a 10,000-hour life.

Another problem being investigated is that of ion beam neutralization. Because this problem cannot be studied in ground facilities with confidence, NASA scheduled Space Electric Rocket Tests (SERT I), ballistic tests using electric rockets. The prototype spacecraft for the study successfully completed preflight tests, including flight simulation tests in a vacuum tank. The flight spacecraft was assembled and was undergoing flight qualification tests. The first flight was scheduled for the 3d quarter of calendar year 1964.

Electrothermal Engine Research and Technology

Electrothermal engines (resistojet, arc jet) develop thrust by expanding and exhausting an electrically heated gaseous propellant such as hydrogen or ammonia. In the resistojet engine, various types

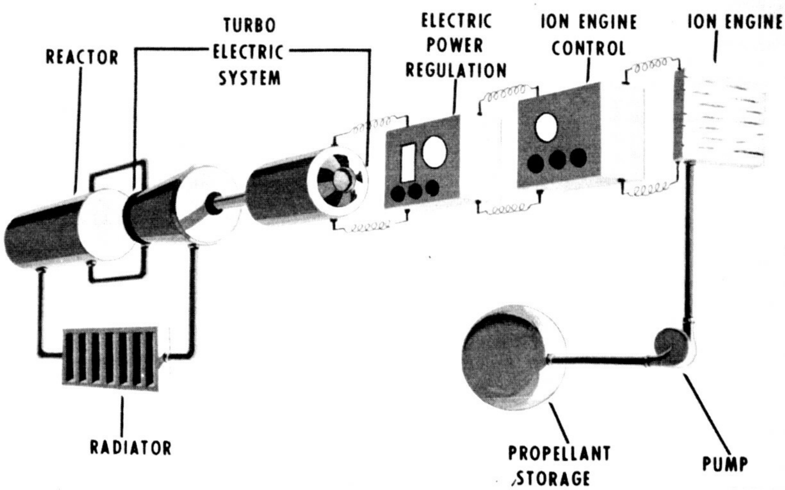


Figure 5–1. Nuclear-electric primary propulsion system (ion engine).

of resistance-heated heat exchangers are used to raise propellant temperature prior to ejection through the nozzle. In the arc jet engine, the working fluid is heated as it passes in and around the thermal arc discharge.

Resistojet.—The resistojet, simplest of all electric thrustors, is capable of extremely high efficiency. However, because of material limitations, the performance of this type of engine is restricted to specific impulse values somewhat less than 1,000 seconds with hydrogen and lower with heavier propellants. The central problem has been designing and developing an efficient, reliable heat exchanger capable of very long life. One design for a 3 kw. thrustor was recently run at a specific impulse of 800 seconds for 50 hours with no measurable deterioration. Also, investigation of a concentric tube heat exchanger was started and pulsed operation of 100 watts to a few kilowatts was going forward. Plans were made for NASA to complete a simulator evaluation of the resistojet for stationkeeping and attitude control application during fiscal year 1965.

Arc Jet.—Radiation-cooled arc jets were operated in several industrial laboratories with sufficient results to determine their performance parameters. Runs exceeded 30 days, with hydrogen as the propellant in most cases, and were voluntarily terminated. They showed that electrode erosion was not severe and is no longer considered a limiting factor. Plans were made for an extended life test at the 30 kw. level during fiscal year 1965.

In general, NASA has concluded that these engines are capable of performance at somewhat better than 1,000 seconds with efficiencies of 40–50 percent. Research into methods of improving both efficiency and specific impulse was continuing.

High Specific Impulse "Arc".—A most significant achievement in electric propulsion technology was attained by A. Ducati, a contractor-employed scientist. His experiments indicated that specific impulses in the range from 3,000 to 15,000 seconds were possible with arc jet-like configurations. NASA put "Ducati effect" accelerators under active investigation at several locations and expected that their applicability to electric thrustor design would be more fully developed.

Electromagnetic Engine Research and Technology

Through the efforts of three major contractors, NASA made substantial improvements in the performance of pulsed plasma accelerators. Over 90 percent of the energy stored in the capacitor bank was delivered to the plasma in the first half cycle of the coaxial gun operation; approximately 55 percent was measured in the exhaust calorimeter. Further improvements appear to be at hand.

Also, energy storage techniques were improved recently by replacing capacitors with distributed parameter pulse lines. These elements not only are lighter but also offer the possibility of improved energy transfer to the plasma.

The Hall current steady flow accelerator (which uses a "Ducati effect" preionizer) operated over the specific impulse range from 1,000 to 8,000 seconds at efficiencies ranging from 20 to 50 percent. Plans were made to investigate lithium seeding as a technique to further increase performance.

The Nuclear Rocket Program

The nuclear rocket program is a joint NASA-AEC endeavor concerned with developing the technology for using nuclear propulsion for space missions. The program includes the KIWI and NERVA projects and supporting research and technology. KIWI and NERVA are expected to develop components and subsystems leading to an experimental, ground-based nuclear-rocket engine. The research and technology effort is concerned with advanced reactor research, the evaluation of alternate concepts, mission applications and requirements, vehicle technology development, and flight safety. Figure 5–2 illustrates a typical manned spacecraft concept using nuclear rocket propulsion.

Figure 5–2. Nuclear rocket propulsion for manned mission.

The KIWI Project

The KIWI project, under the direction of the Los Alamos Scientific Laboratory (LASL), was marked by two major reactor experiments during this report period. Both were tests of the LASL KIWI–B4D reactor design which was engineered to overcome the damaging vibration problems experienced in the KIWI–B4A power tests in November of 1962. These problems were analyzed and verified through a series of KIWI–B4A cold flow tests run in May of 1963.

Following the B4A tests, a B4B cold flow reactor was tested (August 1963) which included simple fixes simulating the redesigned features that were to be incorporated in later KIWI and NERVA reactors (including the KIWI–B4D) to prevent vibration. The cold flow tests of the B4B design showed that these redesigned features would eliminate the core vibration problem, at least under cold flow conditions. The exact redesign was then checked through KIWI–B4D cold flow reactor tests on February 13, 1964. Analyses of the data stemming from these tests and the subsequent examinations indicated that the core support structure performed as predicted and that no vibration occurred.

The second experiment was performed on a KIWI–B4D power reactor (April–May 1964). The primary objectives of this test series were to investigate the structural integrity and dynamic stability of the B4D design under design flow rate; and to measure by means of test instrumentation and post mortem examination the thermal, flow, and neutronic performance for comparison with design predictions. A secondary objective was to obtain information on the effects of operating time with the environmental conditions on the overall test system, including reactor, nozzle feed system, and plumbing. In addition, the tests were designed to provide information on reactor cooldown, using liquid hydrogen, and automatic reactor startup from source power; and to give critical pressure measurements throughout the system.

It had been intended during the KIWI–B4D test to start the reactor automatically, program the power to approximately one-third of the planned power plateau, hold at those conditions to check and calibrate instrumentation, program the power to the planned power plateau and hold for the planned test duration, and program a reduction in power. The planned operating conditions of the run were established considering much previously available data.

All planned conditions were met or exceeded with one exception: the operating time at the power plateau was slightly more than 1 minute rather than the duration planned. This reduction in oper-

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ating time was made necessary by a hydrogen leak external to the reactor which resulted in a fire. Shutdown was accomplished through the normal, preplanned shutdown procedure.

It appears that the power plateau was a little higher than expected. With the power achieved, the test was even more rigorous than had been planned.

The NERVA Project

During the current reporting period, contractors working under the SNPO conducted the first series of cold flow tests on a NERVA reactor configuration (March 1964). These tests, run on a cold flow reactor designated the NRX–A1, were designed to determine the dynamic stability and the structural integrity of the assembly and its components under cold flow conditions and to demonstrate the ability of the various components and subassemblies to perform their functions adequately under cold flow conditions. Preliminary analyses of the test data indicate that the cryogenic runs produced no abnormal pressures, pressure drops, or vibrations. The detailed analyses and post mortem examination of the reactor components were in process.

In the NERVA nonnuclear components area, substantial effort was devoted to developing the major engine components, evaluating their performance in the heat and radiation environment of the reactor, developing a detailed NERVA engine concept, and obtaining an understanding of full system operation. Components receiving major emphasis included the turbopump (used to pump hydrogen from the propellant tank to the engine), the liquid-hydrogen, jet-cooled engine nozzle, and certain essential controls and valves (for example, the turbine power control valve that determines the amount of hydrogen to be bled off from the jet nozzle to power the turbine). In addition, work was underway to develop the nozzle bleed port through which hot hydrogen will be drawn to provide the power to drive the turbine of the turbopump.

Supporting Research and Technology

Besides moving forward with the KIWI and NERVA projects, NASA supporting research and technology efforts include reactor research and nonreactor component development, vehicle technology development, and flight safety.

Reactor Research and Nonreactor Component Development.—The Los Alamos Scientific Laboratory began initial critical experiments on large diameter cores for high-power graphite reactors. These experiments provide the initial nuclear parameter data needed for preliminary design work. The general range of the required fuel loadings was determined, and the effect of substituting various materials in key components was established. Experiments to determine necessary reflector control span were underway.

In addition to the graphite work, Lewis Research Center conducted exploratory investigations on a water-moderated tungsten reactor and the Argonne National Laboratory, on a fast (unmoderated) reactor. The major emphasis was on determining the capabilities of tungsten uranium-dioxide (UO_2) fuel. A number of interesting fine structure fuel shapes were fabricated for evaluation.

In the nonreactor component development area, a cold flow engine simulation test stand (the B–1 stand) went into operation in March. Transient startup tests were run, using gaseous and liquid hydrogen to give data on the behavior of fluids and on engine components during the critical start period. This stand also simulates vacuum start for the nuclear rocket, a capability that will not be available anywhere else for several years.

Vehicle Technology Development.—In anticipation of the ultimate use of nuclear rocket propulsion, NASA had already studied many of the practical problems of nuclear space vehicles (size, trajectories, engine-vehicle integration, launch operations, flight safety, tank pressurization, attitude control, and facility requirements). Further studies were currently underway in the areas of cryogenic flow and handling problems, propellant heating from nuclear radiation, lightweight space vehicle structures, internal insulation, and radiation effects on critical vehicle materials and stage subsystem components.

Flight Safety.—Studies to date indicate that nuclear rockets can be used safely under normal operating conditions or under nonnormal conditions when protected by the use of appropriate countermeasures. Detailed work was continuing to make certain that these countermeasures would be reliable and would not detrimentally affect the reliability or basic operation of the nuclear rocket system.

Facilities

At the Nuclear Rocket Development Station (NRDS), substantial progress was made in providing the necessary facilities for ground testing nuclear rocket engines. The major items now under construction are the Engine Test Stand No. 1 (ETS–1), shown in figure 5–3, which will be used to test the NERVA class of propulsion systems; the Engine Maintenance, Assembly and Disassembly Building (E–MAD); and an Administration and Engineering Building. Work was also continuing on power facilities and on certain access roads.

The brick and mortar work and process piping for Engine Test Stand No. 1 were completed. The design of the instrumentation and control system also was essentially completed and in the procurement stage. The design concept for the exhaust duct was established and the detailed design work was in progress.

The Phase I construction of the E–MAD facility, including the assembly and the shielded disassembly bays, was expected to be completed by September 1964. The construction of the E–MAD hot cells, Phase II, was expected to be completed by December 1964.

Construction of the Administration and Engineering Building was to be completed by July 1964.

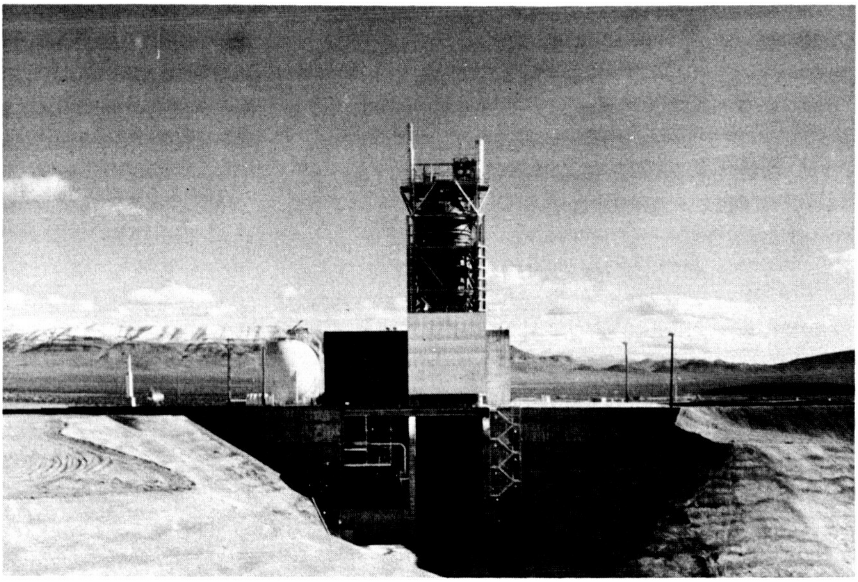
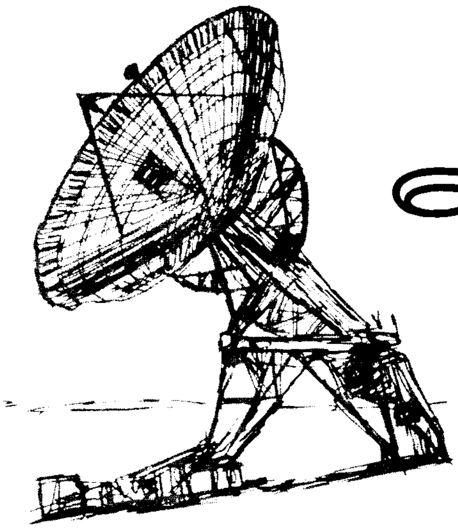


Figure 5–3. Engine Test Stand No. 1, NRDS.



6 TRACKING AND DATA ACQUISITION

During the first half of 1964, the NASA tracking networks continued to provide excellent support in tracking, telemetry, command and data processing for the NASA and DOD programs, including such key missions as the first Gemini unmanned launch, Saturns SA–5 and SA–6, and the Ranger VI. In addition, the Satellite Network supported 17 NASA and 6 DOD satellites.

The program of updating the capability of the networks progressed as scheduled with the installation and checkout of new facilities and equipment. Of major significance was the addition of two 40-foot antennas to the Satellite Network, thereby increasing markedly the data coverage and handling capability in support of the future satellite missions.

The Manned Space Flight Network and the Deep Space Network continued to expand facilities to meet requirements for the manned Gemini missions and for the Mariner and Surveyor missions.

Satellite Network

The Satellite Network consists of 13 electronic tracking stations operated by the Goddard Space Flight Center, and 12 optical stations operated by the Smithsonian Astrophysical Observatory.

The electronic ground stations track, determine the status of, acquire data from, and command the various data functions of satellites. Each is equipped with a communication system for transmitting information to the network operations facilities at the Goddard Space Flight Center. Stations in this network are at Blossom Point, Md.; Fort Myers, Fla.; Quito, Ecuador; Lima, Peru; Santiago, Chile; Woomera, Australia; Johannesburg, South Africa; Goldstone, Calif.; St. Johns, Newfoundland; East Grand Forks, Minn.; Winkfield, England; Rosman, N.C.; and Fairbanks, Alaska.

During the period covered by this report, increased data acquisition and handling capabilities were added by the completion of medium-gain antenna installations (40-foot parabolic dishes) at Quito, Ecuador and Johannesburg, South Africa. The Quito and Johannesburg installations were completed in May 1964.

These 40-foot antennas, in conjunction with the 85-foot antennas at Fairbanks, Alaska, and Rosman, N.C., now provide the Satellite Network with the necessary increased capability to handle the first launchings of the Observatory class satellites—the Eccentric Geophysical Observatory (EGO) and the complex weather satellite Nimbus. These satellites and other large and complex spacecraft, such as the Orbiting Astronomical Observatory (OAO) and the Polar Orbiting Geophysical Observatory (POGO), will carry more experiments to greater distances. They are expected to provide a vast increase in the amount of data gathered, compared with satellites launched to date.

All of these stations will be used for acquiring data from the EGO. Since the EGO will have a highly eccentric orbit, with apogee in the northern hemisphere, the Fairbanks and Rosman 85-foot antenna stations should provide nearly perfect data recovery when the satellite is at apogee. The 40-foot antenna station at Johannesburg is expected to assure realtime data recovery at perigee.

The Fairbanks station, equipped for full data recovery of the Nimbus satellite, should obtain data for approximately 70 percent of the total orbits per day. Additional orbits will be covered by the Rosman, N.C., station.

Directly associated with the Satellite Network is the data-processing function that converts the transmitted telemetry output from the satellite to data in a form usable by the scientific experimenters. This function involves a number of operations, starting at the time the satellite system detects a bit of scientific information and ending when the information is in the hands of the user. The data-processing operation is designed to share available data handling equipment among the maximum number of satellites and the largest possible number of experiments.

The capability to process increasing amounts of data must be continually expanded by the addition of new equipment. Thus, a system was installed to perform a number of data-processing functions, including tape evaluation, signal processing, quality control, and separation of data. This system, called Satellite Telemetry Automatic Reduction System (STARS), has made data available to experimenters at an earlier date and at lower cost than previously possible.

During this period, the electronic Satellite Network supported a total of 23 satellite programs. This total includes 10 satellites launched after January 1, 1964. The new satellites are:

Name	*Date launched*
1964 1B (GGSE)	January 11
1964 1C (EGRS)	January 11
1964 1D (Solar Radiation)	January 11
1964 3A (Relay 2)	January 21
1964 4A (Echo 2)	January 25
1964 5A (Saturn 5)	January 29
1964 15A (Ariel II)	March 27
1964 18A (Gemini/Titan 1)	April 8
1964 25A (Saturn 6)	May 28
1964 30A (Starflash)	June 13

The first 3 satellites and the last one listed above, although under the cognizance of the Department of Defense, were supported by the NASA Satellite Network.

The 12 optical tracking stations operated by the Smithsonian Astrophysical Observatory provided backup support. These stations are in San Fernando, Spain; Mitaka (Tokyo), Japan; Naini Tal, India; Arequipa, Peru; Shiraz, Iran; Curacao, Netherland West Indies; Villa Dolores, Argentina; Mount Haleakala, Hawaii; Olifantsfontein, South Africa; Woomera, Australia; Jupiter, Fla.; and Organ Pass, N. Mex.

These optical stations also provide precision orbital tracking for scientific study purposes. During this report period, they provided orbital data for 11 satellites. Also, they tracked 14 other satellites to obtain data for the precise measurement of atmospheric and magnetic properties affecting satellite orbits.

Deep Space Network

The Deep Space Network is comprised of stations that are used primarily to acquire, track, obtain telemetry data from, and send commands to spacecraft and probes in support of NASA lunar and planetary programs. These stations were further improved and modifications started to meet the Mariner C and Surveyor series spacecraft mission requirements.

The construction of the S-band 85-foot antenna station at Canberra, Australia, progressed according to schedule, with operation estimated for the latter part of this calendar year. Also during this period, construction continued on schedule for the S-band prototype 210-foot parabolic antenna station at Goldstone, Calif. An intergovernmental agreement for tracking operations was signed between the United States and Spain; and construction was started on the S-band 85-foot antenna station near Madrid, Spain.

The control room at Woomera, Australia, was altered to provide additional space for the special supporting equipment of Mariner spacecraft. The Pioneer station at Goldstone, Calif., was modified to accept the S-band equipment for both the Deep Space Network and the Manned Space Flight Network. The evaluation and acceptance of the S-band prototype equipment was accomplished during this period.

After the Ranger VI spacecraft was launched from Cape Kennedy Fla., on January 30, 1964, the Network tracked it from shortly after injection into the lunar transfer orbit on January 30, 1964, until lunar impact on February 2, 1964. The quality of the tracking data was excellent.

The reliability of the communications to Johannesburg, South Africa, was improved by a backup circuit from South Africa to Australia, to Hawaii, to the United States. A microwave circuit was also established between Goldstone, Calif., and the Space Flight Operations Facility at JPL, Pasadena, Calif., for rapid, realtime, wide band data handling. Since the spacecraft's beacons operate in two separate frequency spectrums for the Ranger series, the future Mariner, and the Surveyor space missions, parallel work continued on expanding the network to support these requirements.

The training of key personnel from all stations continued at the Goldstone complex. These people in turn train others at their home stations to maintain optimum performance and efficiency.

At the end of the Ranger Block III series of flights, all stations are scheduled to be modified for S-band operation. The Network was being scheduled to support three space flights simultaneously during certain periods in the next fiscal year.

Manned Space Flight Network

The Manned Space Flight Network, the first realtime worldwide tracking and data acquisition network, was originally established in 1959. Its 16 land-based stations, 2 specially instrumented ships, and a data processing and computing center at Greenbelt, Md.,were being modified to support the Gemini program.

Primary stations are at Bermuda, Cape Kennedy, Canary Island, Carnarvon, Guaymas, Hawaii, Texas, and the Rose Knot Victory and Coastal Sentry Quebec ships. The secondary stations are at Kano, Canton Island, Point Arguello, White Sands, and Eglin. The Gemini launch phase will be supported by the following down range stations of the Eastern Test Range, formerly known as the Atlantic Missile Test Range: Grand Turk, Grand Bahamas, San Salvador, and Antigua.

To provide the required safety and reliable acquisition of Gemini flight data, radar tracking systems were installed at some stations, telemetry systems were installed and combined with the command systems to provide dual capability, and both HF and UHF voice communications were installed. Each of the primary stations is to be augmented with the necessary additional equipment to provide the capability to track, receive telemetered information, command the spacecraft, and communicate with the astronauts either individually or simultaneously. Each secondary station is to have telemetry record and communications capability. A few secondary stations will have tracking capabilities.

A near realtime data processing system was installed at each primary site to select format, convert to teletype, and transmit data back to the control center. Some data is to be displayed at the ground station to provide quick-look information.

During the period under review, three major events were supported by the Manned Space Flight Network: SA-5, launched on January 29; SA-6, launched on May 28; and the Gemini Titan I (GT-1), launched on April 8.

The main purpose of the SA-5 flight (discussed in ch. 1) was to further test the first stage (S-I), to demonstrate separation of the S-I stage and the second stage (S-IV), to test the function of the S-IV propulsion system which uses liquid hydrogen, establish the feasibility of radar skin-tracking the tumbling S-IV stage in orbit, and evaluate the ground stations. This was the fifth in a series of 10 Saturn rockets, and the first to have a powered second stage. The SA-6 flight (ch. 1) was primarily for checkout of an Apollo boilerplate spacecraft.

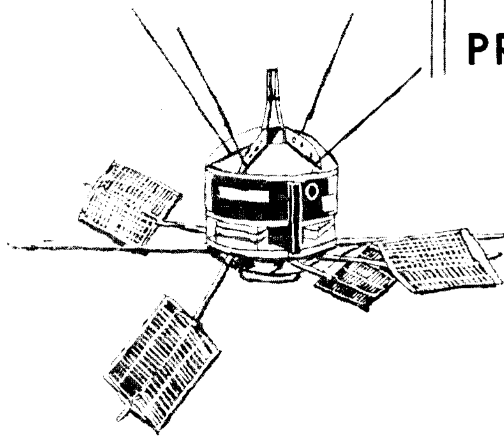
The Gemini Titan I (GT-1) (also discussed in ch. 1) was an unmanned orbital flight to demonstrate the Gemini Launch Vehicle (GLV) performance, to flight-qualify the vehicle subsystems for future Gemini missions, and to demonstrate the ability of the GLV and ground guidance systems to accurately achieve the required orbital insertion conditions. No separation was planned and the spacecraft, adapter, and booster stage orbited for several days. The network provided excellent support for this mission and was being readied for the second Gemini flight.

The Centaur AC–3 flight and Fire I were also supported during this period. Centaur AC–3 was launched to demonstrate the structural integrity of the vehicle, evaluate the second stage propulsion system, evaluate the vehicle design, and evaluate the guidance system's inertial measuring unit. Fire I was launched to investigate the heating environment encountered by a body reentering the earth's atmosphere at 25,000 miles per hour.

Planning and development of the tracking and data acquisition requirements for the Apollo program continued throughout this period. New and advanced electronic systems were being procured.

The Manned Space Flight Network is to be augmented with antennas, command, telemetry, and communication systems which were in the scheduling stage. (This plan also includes instrumented ships to provide coverage not attainable from land stations.)

7 INTERNATIONAL PROGRAMS



Major strides in NASA's international programs were accomplished during the first half of 1964.

Advancing the peaceful uses of outer space in the field of cooperative satellites were the successful launching of Ariel II, a cooperative NASA-United Kingdom scientific satellite, and the decision to launch a French VLF (Very Low Frequency) satellite on a NASA vehicle. Nike-Apache sounding rockets were launched from the Thumba range in South India, from the Norwegian range at Andoya, and from the Sonmiani Beach range in Pakistan (Judi-Dart sounding rockets were also launched from this range).

The first coordinated space research effort between NASA and the Academy of Sciences of the U.S.S.R. was accomplished with the completion of long distance telecommunications via Echo II. Agreements on tracking and data acquisition stations in Australia, Nigeria, and Spain and the testing of experimental communications satellites were concluded. A summary of NASA's international activities is tabulated in appendix L.

Cooperative Projects

During the first half of 1964, NASA passed significant milestones in cooperative projects with France, India, Italy, Norway and Denmark, Pakistan, Sweden, the United Kingdom, and the U.S.S.R.

France

NASA and the French National Center for Space Studies (CNES) agreed in March that sounding rocket experiments at Wallops Island in October 1963 had demonstrated the feasibility of the French proposal to conduct satellite investigations of VLF characteristics above 100 kilometers. This confirmed the preliminary NASA–CNES agreement (of February 1963) to launch a French VLF satellite on a NASA Scout vehicle by early 1966. CNES assumed responsibility for design, instrumentation, fabrication, and testing of the spacecraft and for data reduction. NASA assumed responsibility for launching the spacecraft and for satellite tracking and data acquisition.

On April 11 and 13, at the invitation of CNES, instrumentation prepared by NASA's Goddard Space Flight Center was launched in conjunction with CNES sodium release canisters from the French launching site in Hammaguir, Algeria, on French "Dragon" sounding rockets. This marked the first launching of NASA instrumentation on a foreign vehicle in a cooperative experiment.

India

During January, six scientific experiments were launched successfully on Nike-Apache sounding rockets from the Thumba range in southern India in U.S.-Indian cooperative projects. The first two rockets contained sodium vapor payloads designed to measure winds in the upper atmosphere. The remaining four contained magnetometer payloads designed by the University of New Hampshire to investigate the equatorial electrojet.

Italy

The Italians successfully launched a sodium vapor payload with a Nike-Cajun rocket on March 25 in the first operational test of the San Marco platform, a U.S.-Italian cooperative project. For this launch the platform was located in equatorial waters off the East Coast of Africa. In subsequent launchings on March 30 and April 2, the vehicles performed well, although both sodium vapor payloads failed to function. Since the launchings were primarily to validate the platform, the Italians consider the major aim fulfilled.

Norway-Denmark

On March 12, 15, and 19, as part of a joint U.S.-Norwegian-Danish cooperative program, ionospheric payloads were launched successfully on Nike-Apache sounding rockets from the Norwegian range at Andoya, north of the Arctic Circle. The first two payloads were launched into disturbed auroral conditions; the third was launched into a quiet daytime ionosphere.

Pakistan

On March 18 and April 15, Pakistan successfully launched Judi-Dart sounding rockets from the range at Sonmiani Beach, Pakistan, in a cooperative program with NASA. The program was designed to supplement the meteorological work of the International Indian Ocean Expedition. These launchings will contribute to the comprehensive study of Indian Ocean weather patterns.

On April 9, as part of another cooperative project with NASA, Pakistan launched from Sonmiani Beach a Nike-Apache vehicle carrying a sodium vapor payload.

Sweden

On March 6, as a part of a continuing cooperative effort between NASA and the Swedish Space Committee, a sodium-lithium chemical release payload designed in Sweden for upper atmospheric investigations was successfully launched from Wallops Island, Va., by a boosted Arcas rocket.

United Kingdom

On January 10, NASA and the British National Committee on Space Research (BNCSR) agreed to include two British experiments—a spherical ion mass spectrometer and a planar electron temperature probe—on the Direct Measurement Explorer satellite (DME-A). This particular satellite is expected to be launched in conjunction with Alouette II in 1965 as part of the continuing NASA-Canadian Defense Research Board topside sounder program. BNCSR is to have responsibility for building, testing, and delivering the experiments, and monitoring their performance to countdown.

On March 27, NASA launched Ariel II, the second in a series of three cooperative U.S.-United Kingdom scientific satellites. (See fig. 7–1.) The launch was made from Wallops Island by means of a Scout vehicle. The United Kingdom provided the satellite's three experiments, which have successfully measured galactic radio noise, vertical distribution of ozone, and micrometeoroid flux. NASA's Goddard Space Flight Center was responsible for the design, manufacture, and testing of the spacecraft. It was also responsible for tracking and data acquisition.

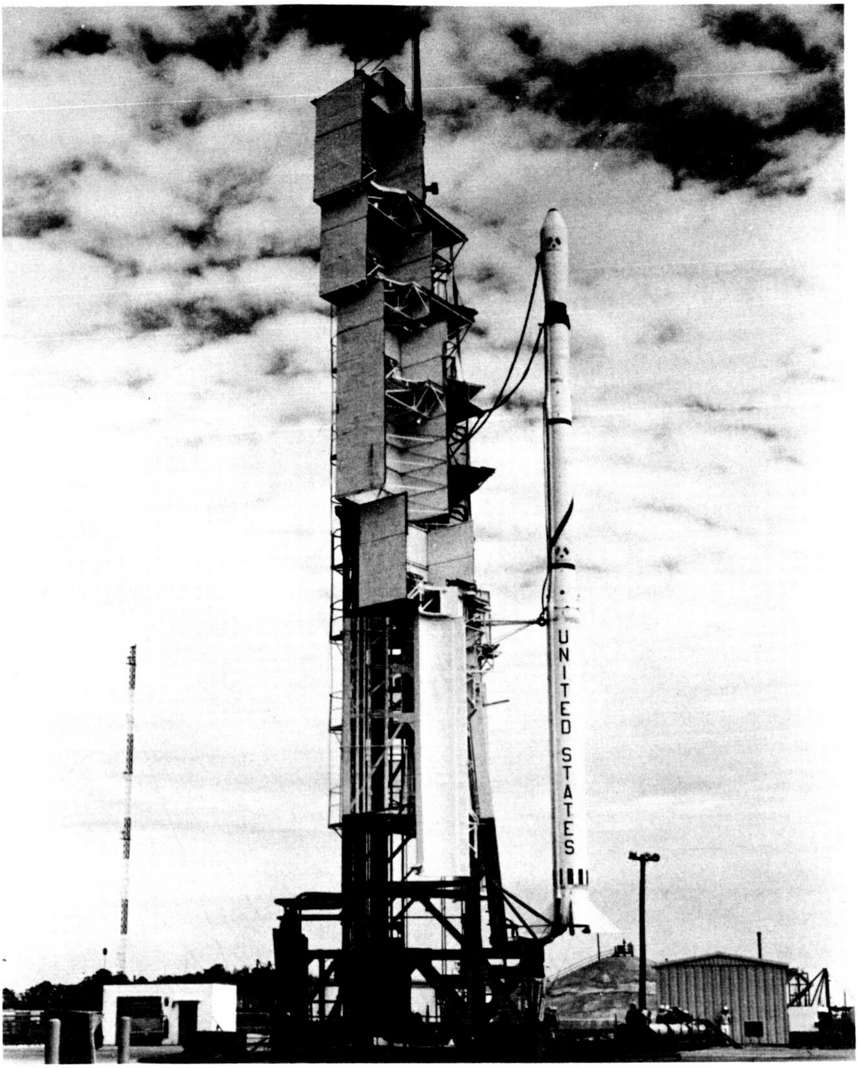


Figure 7–1. Launch of Ariel II.

In April, NASA and the Radio Research Station (RRS) of the United Kingdom Department of Scientific and Industrial Research agreed on arrangements for continued RRS participation in NASA-Canadian ionospheric satellite studies. NASA is to extend the loan of telemetry equipment at the South Atlantic station. RRS will staff and operate telemetry stations at Winkfield (England), Singapore, and the South Atlantic station; make the acquired data available to the joint NASA-Canadian-United Kingdom working group; and share in the work of data analysis.

U.S.S.R.

The first series of joint tests with the Soviet Academy of Sciences of long-distance telecommunications via NASA's passive communication satellite Echo II took place between February 21 and March 9. These transmissions from the Jodrell Bank Observatory in England to the Zimenki Observatory in the U.S.S.R. represented the first specific performance under the terms of the Bilateral Space Agreement of 1962.

Operations Support

During this period, an intergovernmental agreement was concluded with Spain for a tracking and data acquisition station to be constructed near Madrid. The intergovernmental agreement with Nigeria for the manned space flight communications and data acquisition station was renewed. An interagency agreement with the Spanish National Telephone Company was completed, providing for cooperation in testing experimental communications satellites. And arrangements were made for Syncom III ground telemetry and command equipment to be installed in Australia. In this period, also, the new multipurpose tracking station at Carnarvon, Australia, was dedicated and the manned space flight station on Zanzibar was closed.

Australia

An amendment to the Minitrack agency agreement was submitted to the Australian Department of Supply (DOS) in this period. This agreement provided for the location and operation of Syncom III telemetry and command equipment near Adelaide, Australia. Syncom III is scheduled to be launched later in 1964.

NASA's new tracking and data-acquisition station at Carnarvon, Australia, was dedicated on June 25. The station will play a primary role in the manned space flight program; it will also support the unmanned orbiting observatory series of scientific satellites.

Canada

Following the withdrawal of the U.S. Weather Bureau, the international agreement for a command and data-acquisition station in Canada to support an operational meteorological satellite system was formally terminated by an exchange of notes on February 4.

Nigeria

On May 21, the agreement for a NASA communications and data-acquisition station in Nigeria was amended to provide for continued operation of the station until June 30, 1966. It also makes the station available for support of unmanned as well as manned satellite programs.

Philippines

In support of NASA experiments with Syncom III, a ground communications station was established by the Department of Defense at Clark Air Force Base in the Philippines.

Spain

An agreement for a NASA tracking and data-acquisition station to be located 30 miles west of Madrid was signed on January 29. This station is to be used primarily to support the lunar and planetary program. It will also be able to supplement the Manned Space Flight Network as needed.

NASA and the Spanish National Telephone Company signed an interagency agreement on March 24 providing for Spanish participation in the international program for testing of experimental communications satellites launched by NASA. The first demonstration between the United States and Spain took place on May 27.

Zanzibar

The NASA manned flight station in Zanzibar, which has been in a standby status since the last flight in the Mercury project, was removed from Zanzibar in April at the request of the revolutionary Government of Zanzibar.

Cooperation Through International Organizations

In May and June, the Deputy Administrator of NASA served as the United States representative to the meetings of the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space. Also on the U.S. delegation were the Assistant Administrator for International Programs and the Assistant Director of the Goddard Space Flight Center. The Deputy General Counsel was a member of the U.S. delegation to the legal subcommittee meetings in March. During May, NASA officers also supported the delegation of the National Academy of Sciences at the Seventh Plenary Meeting and the Space Sciences Symposium of the International Committee on Space Research (COSPAR).

The European Space Research Organization (ESRO) expressed a desire to locate a Minitrack-type tracking facility in Alaska as part of the overall ESRO tracking network. Following discussions among NASA, the FCC, and the Department of State, an ESRO site survey team explored possible locations in Alaska in June. An agreement between ESRO and the U.S. Government for establishment of the facility, which will be operated by a U.S. contractor, was under negotiations at the end of the period.

Personnel Exchanges, Education, and Training

During the first half of 1964, over 1,900 foreign nationals from 60 countries visited NASA facilities for scientific and technical discussions or general orientation. Visitors included representatives of space programs in Brazil, France, Italy, Pakistan, and United Kingdom, as well as representatives of the European Space Research Organization (ESRO) and the European Launcher Development Organization (ELDO).

In this report period, 33 graduate students from 11 countries studied space sciences at 16 American universities under the NASA International University Fellowship Program. This program is administered by the National Academy of Sciences. Also in this period, 49 postdoctoral and senior postdoctoral associates from 19 countries performed research at NASA centers, including Jet Propulsion Laboratory. This program also is administered by the National Academy of Sciences (with JPL administering its own program) and is open to United States nationals also.

During this period, 48 technicians from 3 countries and ESRO, here at their own expense, received training in space technology at Goddard Space Flight Center, Langley Research Center,. and Wallops Station in connection with agreed cooperative projects.

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8 GRANTS AND RESEARCH CONTRACTS ACTIVITIES

NASA sponsors a wide variety of research in space-related science an dtechnology by universities and nonprofit organizations. This research, including both specific projects and broad multidisciplinary programs, ranges from basic investigations to technological applications. The Agency relies heavily on the university community for fundamental research in support of space flight endeavors, and many of the scientific and technological advances recorded in this report were made possible through NASA-sponsored university research.

Research in space science and technology is sponsored selectively by the Agency in response to unsolicited proposals. Although these proposals may receive support from any NASA program office having a scientific interest and available funds, NASA's Office of Grants and Research Contracts is the focal point for receiving, handling, and distributing them, and for issuing the resultant grants and research contracts. (Summary of these may be found in appendix M.) In addition, this office has programing responsibility for the Sustaining University Program.

The Sustaining University Program

NASA's Sustaining University Program was inaugurated in 1962 to increase university participation in aeronautical and space sciences and engineering, thereby strengthening the Nation's rapidly expanding space program. The Program is designed to increase the future supply of engineers and scientists trained in space-related fields; assist universities to provide additional research facilities for conducting space research; and encourage new, creative approaches to research problems and develop new research capabilities. During this report period, there were a number of significant accomplishments in these three areas.

Training

Under grants to 88 universities, 886 predoctoral graduate students continued their training in space-related fields. One hundred students completed their second year of training, and 786 others completed their first year. These 886 trainees are distributed as follows among the various academic disciplines:

Physical sciences	Entry year		Engineering	Entry year	
	1962	1963		1962	1963
Mathematics	6	58	Mechanical	9	60
Chemistry	14	95	Electrical	5	93
Physics	31	173	Chemical	5	49
Astronomy	4	18	Aeronautical	6	43
Geology	2	21	Nuclear	3	8
Geophysics	0	7	Civil	0	15
Meteorology	1	2	Industrial	0	4
Atmospheric science	0	2	Metallurgical	2	18
Computer science	1	0	Instruments	1	2
			Engineering mechanics	1	25
			Engineering and applied science	0	9
	59	376		32	326

Biological science	Entry year		Other	Entry year	
	1962	1963		1962	1963
Biochemistry	3	6	Space law	1	0
Biology	0	15	Economics	0	3
Botany	0	8	Political science	0	4
Zoology	0	12			
Microbiology	0	3		1	7
Physiology	2	8			
Pharmacology	0	1			
Bacteriology	0	2			
Genetics	0	4			
Food science	0	2			
Psychology	3	16			
	8	77			

During the period of this report, supplemental grants were made to 88 institutions and new grants were made to an additional 43 colleges and universities. Under these agreements, 1,071 new graduate students will commence their training with the beginning of the fall semester, 1964. The training element of the Program thus encompasses a total of 131 institutions and 1,957 predoctoral students. A listing of the 131 participating universities is included as Appendix N.

Research Facilities

A second part of the Sustaining University Program is concerned with research facilities to provide reasonably adequate laboratory space at universities heavily engaged in scientific and technical activities for the space program. The need for more research laboratory space in the universities is evident; it obviously will not be possible for the universities to undertake the work which is required, if the national goals in space are to be realized, unless that need can be satisfied.

NASA has made a total of 20 research facilities grants to universities to date. Of this total, six were made from fiscal year 1962 funds; nine from fiscal year 1963 funds; and five, during the period of this report, from fiscal year 1964 funds.

These latter five grants total $5,700,000 and were as follows:

Texas A. & M. University	$1, 000, 000
University of Maryland	1, 500, 000
Rice University	1, 600, 000
Washington University (St. Louis)	600, 000
Georgia Institute of Technology	1, 000, 000

These five new facilities relate to an extremely broad and important complex of research capabilities:

The Texas A. & M. Activation Analysis Center will allow expansion of the university's vigorous program of research in activation analysis—part of the NASA-sponsored interdisciplinary space-oriented research in the physical, life, and engineering sciences.

The University of Maryland Space Sciences Center, by virtue of its location and use, will promote a maximum cross fertilization of research activities being supported by NASA. These include investigation of the forces between atoms, molecules, and ions at small distances; theoretical studies of interplanetary gas and dust; investigation of psychophysiology in controlled environments; theoretical research on the dynamics of astrophysical plasmas; investigation of techniques for extraterrestrial measurement of low-energy charged particle fluxes in the interplanetary plasma; measurement of atomic transition probabilities of high temperature gases; multidisciplinary research on the application of high-speed computers to space research problems; theoretical and experimental research on gravitational radiation; and experimental studies of perceptual processes.

The Rice University Space Science and Technology Building will facilitate the continuation and growth of its excellent program in the space sciences. Under NASA auspices, Rice was continuing its investigations of performance and flow conditions in very high-speed wind tunnels and conducting extensive research on the physics of solid materials. The investigations included study of basic laws governing the behavior of solids at high temperatures, and analysis of particles and light flux in aurorae and airglow using rocket-borne instrumentation.

During the report period, a grant was made, design completed, ground-breaking ceremonies held, and construction actually started on the Arthur Holly Compton Research Laboratory of Physics at Washington University (St. Louis). This laboratory will enable the University to develop effectively its program of theoretical physics, cosmic radiation, astrophysics, and other space-related work. Among research activities being conducted for NASA are a determination of characteristics of high-altitude, primary cosmic radiation, histological studies on the inner ear, and analysis of the impact of space activities on the national economy.

The Georgia Institute of Technology Space Sciences and Technology Center will accommodate the University's research program in atmospheric sciences, materials and structures, transport phenomena, and systems engineering as they apply to the national space program. Among the research in progress for NASA are investigations of chemical reactions at cryogenic temperatures; photographic, photometric, and spectrographic observations of flames generated at altitudes of 60 miles; solid-to-gas heat transfer studies; and work on chemical reactions at high altitudes and low temperatures.

Design was completed and bids advertised for the Space Sciences Building at the University of California at Los Angeles under a grant that was executed prior to this reporting period.

On the following facilities grants, actual construction was begun: Stanford University—Medical Instrumentation and Exobiology Laboratory; University of California (Berkeley)—Space Sciences Laboratory; University of Colorado—Laboratory for Atmospheric and Space Physics; University of Michigan—Space Research Building; and Lowell Observatory—Planetary Research Center.

Construction of the following university research facilities continued on schedule: Rensselaer Polytechnic Institute—Materials Research Center; University of Chicago—Space Sciences Laboratory; State University of Iowa—Physics and Astronomy Building; University of Pittsburgh—Space Research and Coordination Center; and Princeton University—Guggenheim Research Laboratories.

The Biomedical Annex to the Harvard Cyclotron Laboratory was completed and occupied. This new space has permitted expansion of research on proton interactions with biological materials, studies to determine the shielding criteria for Project Apollo, and studies of the expected biological risk to our astronauts from solar flares.

Under still another grant, construction of an extension to the Physics Building at the University of Minnesota was virtually completed and occupancy was begun. This addition will permit an expansion of research activities in space physics, atmospheric physics, and related areas. These activities already include high-altitude balloon monitoring of cosmic rays and solar phenomena, studies of radiation heat transfer, gamma ray experiments carried on Orbiting Solar Observatory I (OSO–I), development of instrumentation for OSO–II, monitoring of zodiacal light, and studies of the effects of earth satellite environment and launching stresses on biological metabolism.

An important criterion used in selecting facilities grantees is the relative importance to the national space program of the particular fields of research for which the facilities are proposed. Additionally, the urgency of the institution's need for the facilities, based on the extent of its present research and training program supported by NASA, influences the decision to award a grant. The decision is also influenced by demonstrable competence, achievements, and potential for further contribution to the national space program of its scientific staff. Further, the nature or extent of the institution's commitment to work in the space sciences is considered along with the quality of supporting facilities and staff.

The statutory authorizations under which NASA supports the construction of research laboratory facilities at the university are explicit with respect to ownership. Under them, title to facilities constructed or purchased with NASA research and development funds shall vest with the United States, unless the Administrator of the National Aeronautics and Space Administration determines that the interests of the national program of aeronautical and space activities will best be served by vesting title in the grantee. Determination to vest title in the grantee, pursuant to its request, is made by the Administrator on an individual case basis at the time the grant is made.

Maintenance and operation of the facilities are the responsibility of the grantee, and when title is vested in the grantee, it is a provision of the facilities grant that no charge will be made to any agency of the United States respecting the use thereof in connection with any Government-sponsored research.

Research

The research part of the Sustaining University Program is designed to afford universities the maximum opportunity to balance and strengthen existing areas of space-related work and stimulate the development of new ideas and talent. In addition, particular concern is given research ideas presented by the university community which may overlap or fall outside the specific responsibility of an individual NASA organizational element but which are of vital importance to the overall NASA mission.

Each university has a different capability and character, and NASA's relationship with each varies accordingly. In general, the universities participating in this program fall into two groups: Those that have not been heavily supported in space research but have a potential for quality research and can be expected to make strong future contributions; and those universities which presently have substantial amounts of sponsored research and may be made even more effiective by administrative mechanisms which complement the conventional "project" system.

By providing broad, flexible research support to institutions which have not previously been involved in space research to an appreciable degree, a number of excellent research programs have emerged and new talents and skills have been created. A major side benefit of this effort has been the incentive provided for the university researcher to remain at his institution. Thus, he can create an attractive nucleus of interest for young researchers, offsetting the drift of talent to the larger and better known institutions. The effect is to broaden the base of university participation in the space program and increase the overall national capability.

During the period of this report, work commenced at five universities under grants which were actually made during the previous 6 months. These were the University of Denver, University of Florida, Washington University, University of West Virginia, and the College of William and Mary.

Extensions were given the following institutions for continuation of space-related research: Adelphi University, University of Alabama, University of California (Berkeley), University of California (Los Angeles), California Institute of Technology, Graduate Research Center of the Southwest, University of Kansas, University of

Maine, University of Maryland, Massachusetts Institute of Technology, Montana State College, University of Pennsylvania, University of Pittsburg, Texas A. & M. University, and the University of Wisconsin.

New Sustaining University Program research grants were made to the following: Georgia Institute of Technology, Kansas State University, University of Michigan, Michigan State University, Oklahoma State University, University of Virginia, and Woodstock College.

To the university already heavily involved in space-related research, this program provides an opportunity to make more efficient use of its assets. A carefully developed research program, supported on a broad, flexible, and long-range basis, provides valuable augmentation of existing work. It also affords the opportunity to fill gaps in research programs, consolidate existing work, and encourage the development of young researchers and the germination of new ideas.

At the larger institutions, it is NASA policy to promote the combination of several small related "Project" grants into broad programs. Consequently, many of the research grants awarded by the Sustaining University Program to such institutions will contain funds from other NASA offices or will include work specifically related to projects of immediate interest to them. This combination of broad, long-range Sustaining University Program support with project support adds additional strength and flexibility to the universities' research efforts. An important aspect of these grants is that they promote the development of multidisciplinary approaches to the solution of broad problems vital to the success of the space program. They permit the university to bring their many and varied talents into a single effective focal point of research activity.

All Sustaining University Program research grants are for a 3-year period and are on a "step-funded" basis. This process initially provides full support for the first year of effort, two-thirds of desired level for the second year, and one-third for the third year. At the end of the first year, if the work is to continue, a supplemental grant is awarded to continue the program at its full level of effort during the coming year and advance the two-thirds and one-third funding into the following 2 years.

Many of the research endeavors under the Sustaining University Program have just begun to build up momentum. However, several have had sufficient time to demonstrate the unique opportunities that are now available for the development and growth of research activities under this flexible form of sponsorship.

At the University of Denver materials research has received a strong stimulus from this program; an excellent small program of astrophysics is underway at Montana State College; and new space-related physics and engineering programs are being developed at Kansas State University, Maine, West Virginia, Adelphi, Oklahoma State, and Virginia. Texas A. & M. is conducting new and exciting work in plasma physics and engineering of spacecraft structures. At William and Mary, significant contributions have been made toward instrumentation and utilization of the NASA 600 Mev. synchrocyclotron now under construction at the Langley Research Center.

Similarly, at the larger institutions, this program has provided additional strength to existing space-related research projects. At U.C.L.A., for example, new research has been undertaken in astronomy, cosmology, solid state physics, materials research, geophysics, space biology, and plasma physics. Moreover, the institution has used the flexibility and long-range stability provided by the program to broaden and extend existing projects. Examples of these projects include development of new methods for the collection of cosmic dust particles, design and fabrication of a new environmental test chamber for magnetometers, expansion of their capability to process and evaluate data received from space satellites and probes, and the evolution of new ideas and designs for future scientific satellites.

At the Graduate Research Center of the Southwest, Massachusetts Institute of Technology, and Berkeley, Sustaining University Program research grants have operated in a similar manner to stimulate the growth of new concepts and ideas for the development of advanced flight experiments. The University of Maryland Computer Center has developed new techniques for using computer technology in the space sciences and engineering areas. The University of Pennsylvania has created a unique capability in working with unconventional power sources.

At the Univerity of Washington a program of ceramics research—initiated with partial support by the Sustaining University Program—has matured into an important center of such work, with total support from other NASA program offices. The University of Pittsburgh has launched a major space science and engineering effort and has used a grant under this program to add flexibility to the extensive resources they have obtained from nonfederal sources. At the University of Wisconsin's Institute of Theoretical Chemistry, broadly conceived research in quantum chemistry relating to the properties and behavior of fundamental atomic particles is receiving worldwide recognition.

In several instances, the impact of these grants upon the university has been sufficient to result in large matching contributions to the universities' research activity by private donors and local government sources. These grants have thus acted as catalysts to promote and excite the interest of other sponsors with a corresponding increase in the institution's strength.

The Goddard Space Flight Center's Institute for Space Studies is responsible for broad areas of theoretical research, with particular emphasis on astrophysics, plasma physics, and planetary physics as well as the interpretation of data acquired by Goddard scientific satellites. To meet these responsibilities, the Institute has augmented its inhouse capability by establishing a close research relationship with the university community. During the period of this report, 15 Sustaining University Program grants were made to 10 universities working on research projects in direct cooperation with the Institute. Institutes receiving these grants were the University of California (San Diego), Columbia University, City University of New York, University of Minnesota, New York University, Princeton University, Rutgers University, Wesleyan University, Yale University, and Yeshiva University.

Resident Research Associate Program

The Office of Grants and Research Contracts has overall NASA management responsibility for the NASA-National Academy of Sciences Resident Research Associates Program. The Resident Research Associates Program provides postdoctoral and senior postdoctoral investigators of unusual ability and promise with an opportunity for research in the many areas of space science and technology of vital concern to the national space program. These research associateships, which are usually for one year, are tenable at the NASA Research Centers. During this period, approximately 60 scientists were under appointment at Goddard Space Flight Center, Ames Research Center, and the Marshall Space Flight Center. During the coming year, other NASA Centers are expected to participate, specifically the Lewis Research Center and the Manned Spacecraft Center.

Management of Grants and Research Contracts

A new system for financial reporting and control of cash requirements and disbursements was established. It is applied universally to all institutions having multiple grants from NASA . Under this system, grantees report quarterly on individual grant expenditures, aggregate and accumulated expenditures under all active grants, and project cumulative cash requirements anticipated during the next quarter. This procedure of forecasting cash requirements for all active grant support allows more realistic control of the amount of funds advanced to each institution. Although the projection of cash requirements applies only to grants, the expenditure reports apply to both grants and contracts. The expenditure report also provides a measure of information on the utilization of scientific manpower.

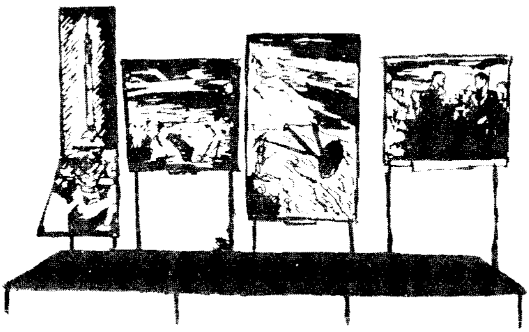
Other management improvements were made during the period of this report. An audit program was developed to provide guidelines for auditing NASA research, training, and facilities grants. Revised procedures were implemented to improve control over proposal processing and to reduce lag time between receipt of proposal and final disposition. Standardized financial report forms were developed for use by training and facilities grantees. These report forms were sent to several universities for review and comment. And Automatic Data Processing Management Reports were developed to reflect total NASA obligations with universities and other nonprofit institutions.

Liaison With the Scientific Community

As part of a continuing effort to improve the NASA relationship with the scientific community, a procedure was initiated to establish a better method of communicating to the scientific community the fields of scientific research of predominant interest to NASA at a given time. Under this procedure, bulletins are distributed to universities and nonprofit research organizations, notifying them of research areas in which NASA has more than an ordinary interest. These bulletins are called "Research Suggestions," and they supplement other sources of information regarding NASA programs and research needs. They provide only general guidance and do not define specific parameters. They should not be considered as requests for proposals, and they do not indicate an impending procurement action.

During the report period one "Research Suggestion" was issued on a trial basis. Well over 100 recipients either responded or acknowledged receipt, and the reaction to the procedure was almost unanimously favorable.

9 INFORMATIONAL AND EDUCATIONAL PROGRAMS



From January through June 1964 NASA, in disseminating scientific and technical information, matched a mushrooming growth of research results and an expansion of its program activities. It achieved this without proportional cost increases through greater inhouse productivity and new and improved methods and techniques.

Educational Programs and Services

In its educational programs the Agency helped more than 200 colleges and universities plan space science courses, provided summer workshop services for about 10,000 teachers, and engaged in adult education projects to increase public understanding of the Nation's space effort. NASA's spacemobile lecture-demonstration teams supplied information on space sciences and exploration to over 1.5 million school children, to teacher training programs, and to civic groups, while spacemobile lecturers made television appearances for over 6 million viewers.

To serve increasing public demands for information on the Nation's civilian space projects and help meet educational needs for the Space Age, NASA's educational-information programs provided nontechnical publications, films, radio, and TV presentations, and exhibits for professional, scientific, and technical audiences and the general public; speakers at meetings of professional, civic, and other groups; and advisory services and program assistance on space science and exploration for educational entities at all levels in nearly every State.

Educational Conferences

During the report period the Agency cooperated with the U.S. Office of Education in sponsoring two national conferences. One was held for State directors of guidance at Langley Research Center, April 13–16; another for State supervisors of science, spacemobile lecturer-demonstrators, and the Subcommittee on Institutes and Conferences, Cooperative Committee on the Teaching of Science and Mathematics, American Association for the Advancement of Sciences at NASA's Western Operations Office, Santa Monica, Calif., May 31–June 5.

One objective of the guidance meetings was to acquaint NASA with what vocational guidance directors consider might be done to keep elementary and secondary school guidance specialists fully informed about the many and varied job opportunities opening up to young people as the result of the Nation's expanding space program. The California conference had among its purposes providing the Agency with an understanding of how schools could be helped in introducing the space sciences into their curricula.

Both conferences sought to give participants an opportunity to increase their knowledge of recent aerospace developments and thereby update their programs.

Materials of Instruction

To meet the instructional needs of schools, colleges, and universities in space science and technology, NASA assisted in developing space-education materials.

Cooperating with the National Science Teachers Association and with various college aerospace institutes, the Agency developed supplements to classroom teaching for instruction in space-related science and mathematics and the activities and progress of the space program. Published and distributed during the reporting period were: *Teaching to Meet the Challenges of the Space Age*—a comprehensive curriculum guide for elementary teachers with space-oriented units and activities at all levels and in all subject areas; and *What Makes a Rocket Go?*—a film and illustrative teacher guide demonstrating classroom procedures in teaching fundamental space-science concepts. (The latter was being given a final experimental tryout.)

In press or in final editorial stages were a syllabus for an adult education lecture series developed by the Rhode Island State Department of Education; a series of six science guides for elementary teachers developed in cooperation with the National Science Teachers Association; and *Spacecraft Construction*, a set of detailed plans for science and industrial arts teachers to use in building models of NASA space vehicles.

Summer Workshops and Courses

NASA disseminates space-science information through college and university extension services and summer workshops for teachers. These programs provide teachers with up-to-date space science knowledge, acquaint them with space literature, and provide ways to adapt this information to classroom use.

During the first 6 months of 1964 NASA helped more than 200 colleges and universities plan space science courses and arrange summer workshop services for about 10,000 teachers.

Adult Education

Through its participation in various adult education programs the Agency helped to increase public understanding of the Nation's space effort.

For example, the adult education pilot project in the public schools of Warren, R.I., "Mankind and Space", undertaken by NASA and the Rhode Island State Department of Education, determined the feasibility of conducting this type of program in the space sciences at a location remote from the resources of one of the Agency's research centers. (See the *10th Semiannual Report*, ch. 9.) A report on the project was being readied for publication and will be made available to State departments of education, local school districts, YWCAs, and others interested in adult education.

NASA also participated in a number of individual programs for adult audiences. Educational programs and services staff members and spacemobile teams gave 172 presentations for about 40,000 members of civic, business, and professional groups. And at the request of the Foreign Service Institute, Department of State, a NASA presentation on space science and exploration was incorporated into the regular program of the foreign service officer orientation course given every month for those beginning overseas assignments.

Youth Programs

NASA for the fourth consecutive year took part in a National Science Fair—International designed to foster scientific interests in secondary school students. Twelve of the Agency's scientists served as judges at this 15th science fair held in Baltimore, Md., May 6–9. Two certificates of merit were awarded in each of the following space categories: Aerodynamics and space flight, electronics and communications, life sciences, physical sciences, propulsion systems, and vehicles. Each winner of a NASA award was invited to visit one of the Agency's field installations accompanied by a teacher of his choice.

The Agency also presented certificates of outstanding achievement in the space sciences at local, regional, and State science fairs. Approximately 200 requests for NASA awards and/or judges were received from science fairs during the first 6 months of 1964.

At the request of Science Service, NASA participated in the Science Talent Institute in Washington by arranging "prime time" appointments with Agency personnel for two science talent search winners. One student had interviews with staff scientists from NASA headquarters; the other spent a day at the Goddard Space Flight Center.

The Agency is assisting the National Council of the Boy Scouts of America in developing requirements for a merit badge on space exploration.

Spacemobiles

From January through June of 1964, 25 spacemobile lecture-demonstration teams provided information on NASA's space science and exploration programs to more than 1.5 million school children, teacher training programs, and civic groups. Spacemobile lecturers also made 12 radio presentations and their 38 television appearances supplied space information for over 6 million TV viewers.

Special spacemobile activities included participation in conferences of the American Industrial Arts Association, National Association of Elementary School Principals, National Council of Teachers of Mathematics, State Department of Education Guidance Directors (Project "Moon Harvest"), and the Fourth Annual Conference on the Peaceful Uses of Space.

Spacemobile lecturers also continued to explain the Agency's space program to teachers and students in Central and South America, Europe, Africa, and the Far East.

Educational Publications and Films

During the first 6 months of 1964 NASA released several new publications, issued updated editions of previously published ones, and reprinted a number of articles from periodicals—all supplied to the requester without charge. In addition, the Agency made substantial progress in planning and producing a number of motion pictures to be made available to the general public without cost.

Publications and films currently available are described in appendix H.

Film Depository Services.—By the end of the report period, NASA had catalogued and stored 5,986,416 feet of motion picture film. About 84,000 feet of film was made available to producers of educational and documentary movies and telecasts.

Educational TV and Radio

"Space: Man's Great Adventure," a series of 4 television documentaries, was produced and released to 89 educational stations. The 30-minute programs for high school and adult audiences document major developments in the space program. These and other programs in the continuing series also will be made available to interested commercial TV stations.

"Science Reporter," a series of eight 30-minute television interviews with prominent space authorities, was distributed for broadcast to in-school and adult audiences by 84 educational television stations.

Requests were answered for assistance from more than 2,000 radio and 200 television stations. This assistance included provision of production aids (films, photographs, slides, and audio tapes), background information, and publications. NASA also helped each of the major commercial networks plan and produce space-oriented programs.

"Space Story," a weekly 5-minute radio report, was produced and distributed to radio stations requesting this service, and was made available for overseas broadcast by the Voice of America and the Armed Forces Radio Network. A series of 10 half-hour radio programs was produced from proceedings of the Annual Conference on the Peaceful Exploration of Space and made available to interested stations.

Exhibits

During the first 6 months of 1964 NASA's 384 exhibits here and abroad portrayed the accomplishments of the Nation's space program for over 6 million people. The principal exhibit of the period was the outdoor U.S. Space Park at the New York World's Fair. Jointly sponsored by the Agency and the Defense Department, with the financial support of the New York World's Fair Corp., the 2-acre park opened on April 22 with the most outstanding collection of full-scale rockets and spacecraft ever assembled outside of Cape Kennedy.

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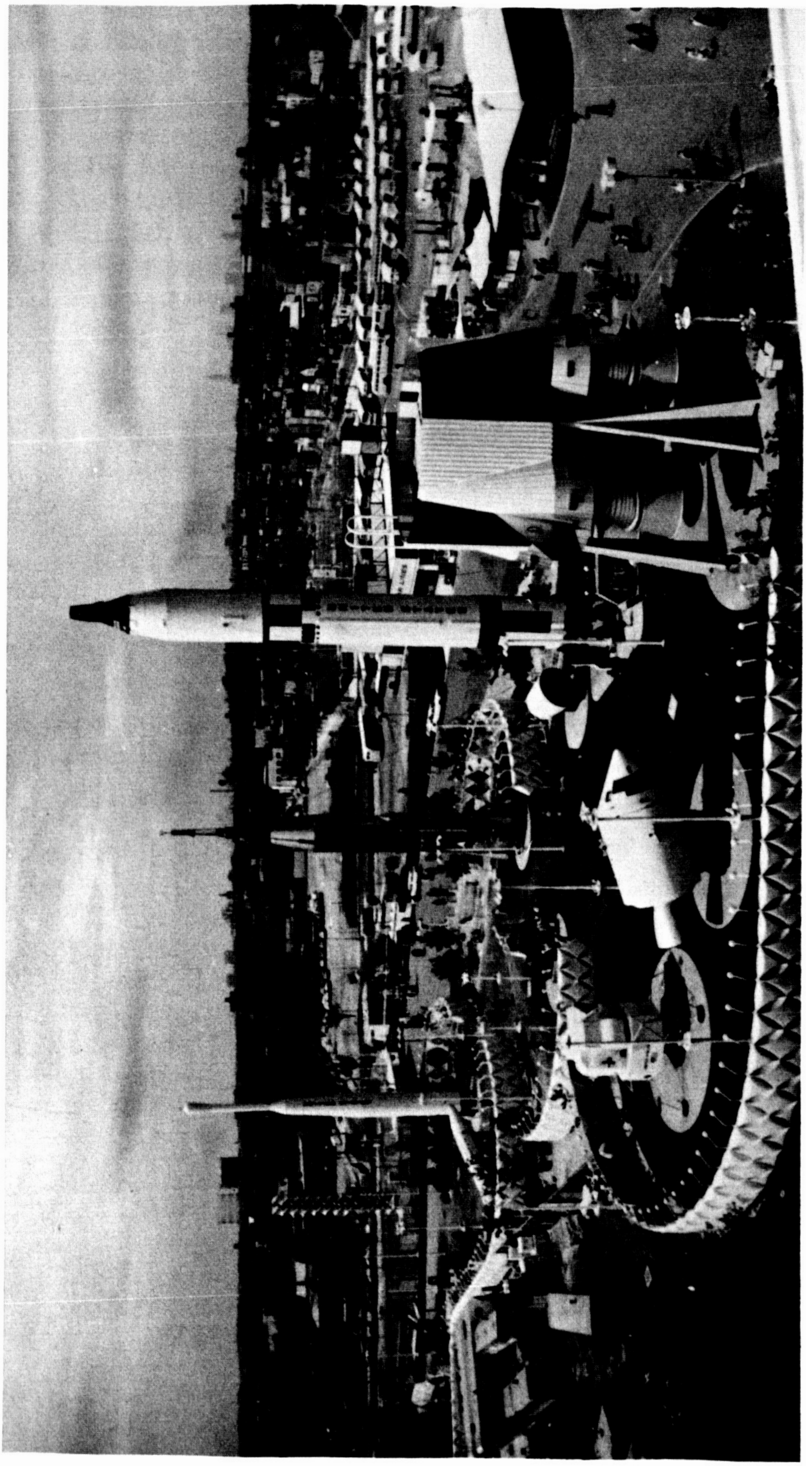


Figure 9–1. U.S. Space Park, New York World's Fair.

Highlighting the exhibit (fig. 9–1) are full-scale models of the aft end of the Saturn V rocket of Project Apollo, which will send American astronauts to the moon, and Astronaut Carpenter's Project Mercury spacecraft. Towering over the park is a Titan II-Gemini launch vehicle and its two-man spacecraft. Among other full-scale exhibits are the Apollo command and service modules, the lunar excursion module, Atlas-Mercury and Thor-Delta rockets, an X–15 rocket-powered research aircraft, the Agena rocket, and models of geophysical, communications, and meteorological satellites. (Exhibits are updated to reflect the latest successful launches.)

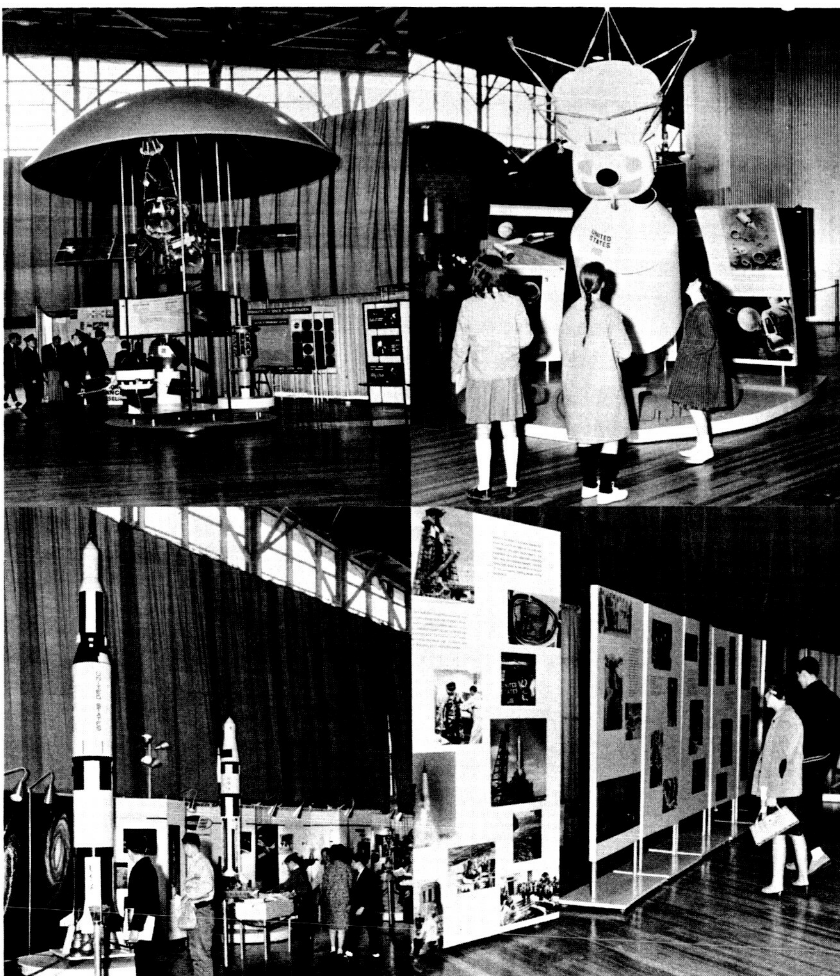


Figure 9–2. NASA exhibits at 4th Annual Conference on Peaceful Uses of Space, Boston, Mass.

Another major domestic exhibit of the report period was a 15,000-square foot display at Northeastern University in conjunction with the Fourth Annual Conference on Peaceful Uses of Space held in Boston, Mass., April 29–May 5 (fig. 9–2). The three-dimensional exhibits—featuring an actual Project Mercury spacecraft and a full-scale model of Saturn I aft end along with continuous demonstration lectures—afforded the visiting public an opportunity to learn about NASA's various space programs.

Future expanded educational exhibits will emphasize Projects Gemini and Apollo, at the same time offering an overall view of United States progress in space science and technology.

Conferences and Speakers Services

NASA participates in, sponsors and cosponsors conferences for professional, scientific, and technical groups to disseminate information on space sciences and technology. Some of the subjects covered by these conferences during the report period were flight mechanics, thermal radiation of solids, industrial applications of new technology, space nutrition and related waste problems, aerospace propulsion, atmospheric biology, transformation of knowledge and its utilization, advanced research and technology, and space radiation effects in cellular systems.

Other major conferences included the Fourth National Conference on Peaceful Uses of Space, Boston, Mass., April 29–May 2; Tenth Annual Meeting of American Astronautical Society, New York, N.Y., May 5–7; International Biophysics Meeting, Paris, France, June 19–29; and First Annual Meeting and Technical Display of the American Institute of Aeronautics and Astronautics, Washington, D.C., June 29–July 2.

The Agency also provides speakers for meetings ranging from national scientific and educational symposiums to regional, State, and local conferences and gatherings. From January through June 1964 NASA officials from headquarters and field installations spoke on the results of the Nation's space program before almost 1,000 of these meetings.

Scientific and Technical Information

The first 6 months of 1964 saw NASA expand its scientific and technical information activities and services to match a rising flow of research results and to meet its immediate program needs, all without proportional cost increases. As summarized by the following highlights of this report period, these increasing requirements for information were met by the Agency through greater inhouse productivity, refinement of present methods, and the development of new techniques.

Computer Storage-Retrieval System Improved

NASA's abstract journal *Scientific and Technical Aerospace Reports* (*STAR*) is used throughout the aerospace community. Less well known outside the Agency is its computer-based information search system which permits a comprehensive search of the NASA collection. This system uses magnetic computer tapes covering reports announced in *STAR* and articles from journals announced in *International Aerospace Abstracts* (published by the American Institute of Aeronautics and Astronautics with NASA support).

General refinements of these search tapes, begun during the first 6 months of 1964, included rearranging information storage for more efficient retrieval and programing for larger computers which are becoming increasingly available. The tapes were sent to an expanding number of local users—NASA's research centers and its principal contractors, and university research centers—and are used also in the Agency's Scientific and Technical Information Facility where the tapes are prepared and updated.

Distribution of *STAR* was also increased and its four-volume annual cumulative index produced and distributed in a record-setting 30 days after the close of the year covered.

Selective Dissemination of Information Tested

Extensive development work was done on NASA's Selective Dissemination of Information (SDI) program. This computerized method—a logical outgrowth of the computer-based information search system—provides individual scientists and engineers with quick, job-tailored announcements of new reports.

Five hundred NASA volunteers continued to participate in developmental tests of this novel system during the report period. These were tests of various methods of creating and matching each man's "interest profile" (subject terms and phrases related to his work and interests) with subject indexes of reports annotated in current issues of *Scientific and Technical Aerospace Reports*.

Following the developmental phase of the SDI program, this new method will be decentralized for economical use by the Agency's research centers and principal contractors.

Interagency Agreement on Microfiche Standards

During the first 6 months of 1964 increasing acceptance by other Government agencies of NASA's microfiche—a miniaturized version of a research and development report—resulted in further standardization of its size and format. (In April 1963, NASA and the Atomic Energy Commission had agreed to develop identical standards for reduction ratios and frame spacing in their microforms.) In addition, the Federal Council for Science and Technology directed all executive agencies to adapt the microfiche method for their reports. These developments paved the way for commercial suppliers to concentrate on simpler, more efficient, and less costly designs of equipment to produce microfiches and promised Federal agencies savings in time and money by using one another's miniaturized reports of this type.

Introduced in January 1962, the microfiche is a 4- by 6-inch transparent negative upon which microfilmed pages of a document are arranged in successive rows. This negative can be used for reading the document, reproducing a photographic copy of it, or making other microfiche for additional distribution—features which provide fast access to new information.

Continuing Bibliographies

Numerous reference tools were being devised to help NASA and its contractors gain ready access to report and journal literature in the Agency's space science and technology information system which might otherwise be overlooked. Among the steps taken were the inauguration of a comprehensive program to prepare continuing bibliographies on selected areas of high interest to the aerospace community. Representative bibliographies are the following ones, drawn from report and journal literature and entered into the information system between January 1962 and June 1964. (Upon publication they will be sold to the public by the Office of Technical Services, U.S. Department of Commerce.)

1. *High-Energy Propellants* (NASA SP-7002)—About 230 references on high-energy rocket fuels which emphasize research and development studies on solid, liquid, and hybrid propellants and oxidizers.
2. *Lunar Surface Studies* (NASA SP-7003)—About 440 references on lunar-surface studies with particular emphasis on theoretical studies of lunar origin, lunar atmosphere, and lunar physical characteristics providing a "baseline" of knowledge for measuring future findings.
3. *Communications Satellites* (NASA SP-7004)—Almost 330 references, including specific and detailed works on passive, active, and synchronous satellites.

4. *Bibliographies on Aerospace Science* (NASA SP-7006)—Lists about 420 broad and specific bibliographies prepared by NASA and others in the aerospace field.

5. *Aerospace Medicine and Biology* (NASA SP-7011)—The first issue of a bibliographic listing of more than 1,000 selected unclassified reports and journal articles describing the biological, physiological, psychological, and environmental effects to which man is subjected during and following simulated or actual flights in the earth's atmosphere or in interplanetary space. Supplements to the first issue, identified as SP-7011 (01) and SP-7011 (02), will be published as the accumulation of new material warrants.

6. *Extraterrestrial Life* (NASA SP-7015)—Part I of a comprehensive annotated bibliography which contains 175 references presenting the results of an extensive search of foreign and domestic report literature on the quest for extraterrestrial life. Part II (to be published) will contain about 850 references to journal articles and books.

Technical Publications

The continuing expansion of the Agency's research and development work was reflected in the mounting number of its scientific and technical reports and of NASA-authored articles in scientific and technical journals. NASA's special publications containing scientific or technical information derived from or of value to the national space program were also released in larger numbers during the reporting period. (See appendix I for listings.)

Historical Program

NASA's historical staff undertook numerous special projects during the first 6 months of 1964 the most complex of which was participation in the Government-wide oral history and documentary program supporting establishment of the John F. Kennedy Memorial Library at Harvard University. The staff identified and collected key documents of the civilian space program during the Kennedy Administration and interviewed leaders in the Nation's space effort who either knew the late President or had been in contact with him in connection with their official duties.

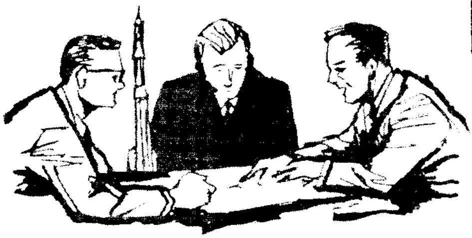
To stimulate the study of the history of astronautics Agency historians worked with the history committees of the International Academy of Astronautics, the American Institute of Aeronautics and Astronautics, and the National Space Club. (NASA's historian became the chairman of the new historical committee of the Institute.)

Collaborating with the Society for the History of Technology, the Agency's historian edited a revised, expanded version of "A History of Rocket Technology" which will be published in book form. The original appeared as the fall 1963 issue of *Technology and Culture*, the quarterly of the Society.

The Agency also issued a revised edition of its illustrated pamphlet on the *Historical Origins of NASA*. (Copies are sold by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 15 cents.)

In May NASA's Historical Advisory Committee held its first meeting in Washington, D.C., chaired by Professor Wood Gray of George Washington University.

10 PERSONNEL, MANAGEMENT, PROCUREMENT, AND SUPPORT FUNCTIONS



During the period, NASA continued seeking means of improving its nontechnical activities in order to provide the necessary support for its increasingly complex missions. In the personnel area, for instance, the Agency moved ahead in its efforts to further improve the effectiveness of its employees and to make certain that the most competent people were selected to fill vacancies. It made still more improvements in its organizational structure to carry out the full intent of the agencywide realinement of functions that took place on November 1, 1963. Also, the Agency continued to conduct its financial affairs in the most efficient and economical manner possible, and to improve its procurement techniques in order to meet the requirements of the complex space programs.

Personnel

NASA's personnel efforts stressed employee-management cooperation, training programs, and equal employment opportunities for all citizens. Other personnel activities included a continuing recruitment program, executive personnel changes, and special recognition of individuals and groups.

Employee-Management Cooperation

NASA took specific steps to carry out the Government-wide Employee-Management Cooperation in the Federal Service Program (Executive Order 10988). Negotiation sessions were conducted between the Washington Area Metal Trades Council and the Goddard Space Flight Center to develop a collective agreement on personnel policies and practices within the Goddard's Wage Board bargaining unit.

The advisory arbitration decision of the appropriate unit question at the Marshall Space Flight Center was rendered. The machinists' craft unit, proposed by the International Association of Machinists, was found to be inappropriate; however, the installationwide unit supported by management and the American Federation of Government Employees was found appropriate.

New bids for exclusive representation by employee organization locals were either presented or under discussion at three NASA installations—Lewis, Marshall, and Kennedy.

Seminars and Training Programs

NASA continued conducting numerous seminars and training programs to further develop and maintain the high levels of knowledge and skill required of NASA employees. These included the procurement management seminars, incentive contracting seminars, NASA–PERT and companion cost system workshops, NASA–PERT for facilities management workshops, supervisory training courses, management development courses, management intern training, graduate study programs, the cooperative education program and apprenticeship training programs.

Procurement Management Seminar.—The procurement management seminar was developed to teach technical personnel the procurement process from the initial planning stages through the precontract and contract administration phases to contract completion. This seminar emphasizes those points in the procurement process with which the technical man is directly concerned. These include establishment of procurement requirements, technical evaluation of contractor proposals, technical consultation with prospective contractors, initiating change orders, control of contractor use of overtime, and termination of contracts. Over 350 NASA employees received this training during the period.

Incentive Contracting Seminar.—This seminar was designed to teach program and project engineers and contract specialists the incentive features of NASA contracts, including fixed price and cost-plus incentives. Subjects covered were the examination in detail of cost, time, and performance provisions; the establishment of targets and ceilings; various incentive formulas; and the multiple incentive provisions. Approximately 330 NASA employees attended these seminars during the period.

NASA–PERT and Companion Cost System Workshop.—This workshop was designed to teach technical and management personnel the objectives, operation, and benefit of NASA's program evaluation and review techniques. Between January and June, 250 employees participated in this workshop.

NASA–PERT for Facilities Management Workshop.—This workshop was designed to train personnel engaged in facility construction management in the objectives, operation, and benefits of network planning techniques. It highlights the application of NASA–PERT to facility construction projects during their total life cycle. In particular, it emphasizes the use of the system during the preliminary planning and early design phase as well as during the research and development phases. Approximately 240 employees were trained during the period.

Supervisory Training Courses.—The purpose of these courses is to teach supervisors throughout the Agency, on a decentralized basis, the current methods of effective utilization of men, money, and materials. Major topics include planning, organizing, executing, decision-making, controlling, and motivation. Three hundred NASA employees were trained during 1963, and 200 during the first half of 1964.

Management Development Courses.—These courses were used to teach management personnel throughout the Agency the various techniques and tools required to effectively carry out their responsibilities, This training consists of a variety of courses, conducted by universities, other Government agencies, and professional training organizations. Approximately 400 employees received this training during the period. (There were 500 NASA employees trained during 1963.)

Management Intern Training.—This program was established to prepare outstanding young college graduates for careers in research and development administration. This training includes rotational assignments, orientation lectures, special assignments, and graduate study. There were 20 recent college graduates trained during 1963. Plans called for training 27 during 1964.

Graduate Study Programs.—NASA's graduate study programs were designed to provide opportunities for talented, motivated, and creative people to enhance their knowledge through graduate study in academic fields appropriate to their work. Over 900 employees received this training during the period. (There were 1,558 NASA employees trained during 1963.)

Cooperative Education Program.—This program, designed for undergraduate scientific and technical college students, provides an integration of academic study at leading universities alternated with practical work experience at NASA installations. Four hundred students participated during the first half of 1964. (There were 770 college students trained during 1963.)

Apprenticeship Training Program.—This program offers training designed to provide an apprentice with comprehensive instruction in the principles and practices of a particular trade or craft as well as in academic or related subjects. It insures a continuous flow of skilled craftsmen thoroughly trained in the trades and crafts peculiar to NASA's field installations. About 250 apprentices were trained between January and July. (There were 443 apprentices trained during 1963.)

Equal Employment Opportunity

The Personnel Division continued implementing the Affirmative Action Program for Federal Employment as required under Executive Order 10925. This program is intended to assure better use of our manpower resources by reassignment of minority group employees to obtain greater skill utilization, by increased employment of qualified minority group persons, and by seeking to interest Negroes and other minority group persons to qualify for scientific and engineering positions available with NASA and other Government agencies.

To implement the Affirmative Action Program, NASA installations were undertaking certain specific activities. For one thing, they were developing skills profiles on minority group employees to determine that the best use of their skills was being made. For another, they were participating with the Urban League in its Skills Bank Program to identify possible minority group candidates for employment. For a third, they were increasing their employment of qualified minority group individuals in student cooperative training and summer employment programs. As a fourth activity, they were using career opportunity conferences at the high school and college level to interest minority group students in qualifying for scientific and technical careers with the Government. And in a fifth area, they were assisting secondary schools and trade schools in acquiring surplus Federal property for the improvement of curricula and physical plants.

Status of Personnel Force

NASA increased its staff from 30,069 employees to 32,499 during the period December 31, 1963–June 30, 1964. The distribution by installation was:

Organization:	Dec. 31, 1963	June 30, 1964
Ames Research Center	2,116	2,204
Flight Research Center	618	619
Goddard Space Flight Center	3,443	3,675
J. F. Kennedy Space Center	1,269	1,625
Langley Research Center	4,234	4,330
Lewis Research Center	4,760	4,859
Marshall Space Flight Center	7,227	7,679
Manned Spacecraft Center	3,364	4,277
North Eastern Office	30	33
Pacific Launch Operations Office	19	22
Wallops Station	502	530
Western Operations Office	318	376
Headquarters	2,017	2,158
AEC/NASA Space Nuclear Propulsion Office	102	112
Total	30,069	32,499

Key Executive Personnel Changes

During the period, a number of changes occurred among NASA's key executive personnel. These included six new appointments, five reassignments, and three terminations.

Key Appointments.—On February 1, 1964, Col. Clarence J. George was appointed Executive Secretary to develop and direct an executive secretariat program covering the functions and operations of agency general management. Prior to his retirement from the Army, Colonel George had been serving as Assistant Secretary of the Staff and Liaison Officer to the Headquarters, Supreme Allied Powers, Europe.

On April 1, 1964, Vice Adm. Rufus E. Rose was appointed Director, Policy Planning Division, within the Office of the Assistant Administrator for Technology Utilization and Policy Planning. Admiral Rose had retired from active duty March 31, 1964, after serving as Assistant Chief of Naval Operations, Defense Advisor to the U.S. Ambassador to NATO, and from 1961 as Commandant, Industrial College of the Armed Forces.

On April 21, 1964, W. Randolph Lovelace III, M.D., was appointed Director of Space Medicine within the Office of Manned Space Flight. Dr. Lovelace came from the Lovelace Clinic and Lovelace Foundation with which he has been associated from 1946.

On June 1, 1964, Breene M. Kerr was appointed Deputy Assistant Administrator for Technology Utilization. Mr. Kerr had been associated with the Kerr-McGee Oil Industries, Inc., from 1953; he came to NASA from the position of Manager of the Land Department of the corporation.

On May 18, 1964, Joseph T. Dickerson, Jr., was appointed Special Assistant to the Associate Administrator for Manned Space Flight.

Mr. Dickerson served as Executive Vice President of the Mid-Continent Oil and Gas Association from 1960, and had previously served in various executive capacities with the Shell Oil Co. and its subsidiaries.

On June 29, 1964, George Friedl, Jr., was appointed Deputy Associate Administrator for Industry Affairs. Mr. Friedl had retired from the Litton Industries, Inc., Beverly Hills, Calif., in May 1960, with which he had been associated in a number of key executive capacities from 1955. From 1960 until his appointment Mr. Friedl had served in various consultive capacities and in community affairs.

Reassignments.—On May 24, 1964, George J. Vecchietti was appointed Director of Procurement. He had been serving as Acting Director of Procurement from February 7, 1964, and had come to NASA as Assistant Director of Procurement and Supply.

On January 12, 1964, Adelbert O. Tischler was reassigned from Assistant Director of Launch Vehicles and Propulsion to Director of Chemical Propulsion Programs in the Office of Advanced Research and Technology. Mr. Tischler had previously served as Chief, Liquid Rocket Program and Chief, Large Engine Rocket Program.

On May 17, 1964, Earl D. Hilburn was made Deputy Associate Administrator. He had previously served as Deputy Associate Administrator for Industry Affairs.

On February 16, 1964, George M. Low was reassigned as Deputy Director of the NASA Manned Spacecraft Center, Houston, Tex. He had, from November 1, 1963, served as Deputy Associate Administrator for Manned Space Flight.

On May 19, 1964, Alfred J. Eggers, Jr., was appointed Deputy Associate Administrator for Advanced Research and Technology. He had been serving as Assistant Director for Research and Development Analysis and Planning at the NASA Ames Research Center.

Terminations.—Walter C. Williams resigned April 24, 1964, from the position of Deputy Associate Administrator for Manned Space Flight Operations. From November 1, 1961, to November 1, 1963, he had served as Deputy Director of the NASA Manned Spacecraft Center. Before that he had served as head of the Project Mercury Flight Operations Group of the former Space Task Group, and as Director of the NACA/NASA Flight Research Center, Edwards, Calif.

James C. Elms resigned January 31, 1964, as Deputy Director for Development and Programs, NASA Manned Spacecraft Center, in which capacity he had served from February 11, 1963, when he joined the staff of the Center.

Walter L. Lingle resigned May 15, 1964, from the position of Deputy Associate Administrator in which he had served from November 1, 1963. He had come to NASA June 25, 1962, and had served as Special Assistant to the Administrator, and as Assistant Administrator for Management Development (and) Deputy Associate Administrator for Industry Affairs.

NASA Awards and Honors

During the period, NASA gave special recognition to certain individuals and groups for their contributions and accomplishments to the Nation's space program.

NASA Medal for Outstanding Leadership—De E. Beeler, Flight Research Center: For his outstanding leadership in the successful conduct of the flight research activities at the Flight Research Center associated with the Research Airplane Program from the X–1 through the X–15.

NASA Certificate of Appreciation.—Five individuals received this award. They were:

James E. Love, Flight Research Center: For his superior leadership in the coordination and management of the X–15 Research Airplane Project team and his devotion to the attainment of the goals of this national flight research program.

Joseph R. Vensel, Flight Research Center: For his outstanding direction of the entire X–15 flight operation in a safe and efficient manner, thereby contributing to the success of this national flight research program.

James C. Elms, Manned Spacecraft Center: For his outstanding participation in reorganizing and managing the Manned Spacecraft Center during the period of its rapid growth and transition from Project Mercury to the Gemini and Apollo projects.

Mervin Kelly, Consultant: For significant contributions to the Nation's space program and particularly to the Apollo Manned Flight System, while serving as consultant to the Administrator and as Chairman of the Management Advisory Committee for Manned Space Flight.

Brig. General Thomas J. Hayes III: For his substantial contribution to the Nation's space program through skilled direction of the Army Corps of Engineers' execution of and support to the NASA's construction program, particularly in the planning, design, and construction of the massive and complex structures required for the manned space flight systems.

NASA Group Achievement Award.—Presented to Flight Test Organization, Flight Research Center, for outstanding accomplishments during the X-15 flight research program, from the first flight on June 8, 1959, to the one hundredth flight on January 28, 1964. (Recipients included personnel of the U.S. Air Force and U.S. Navy.)

This award was also presented to the Automatic Data Processing Branch, Administrative Services Division, Office of Administration, for its efforts in developing, installing, and administering the automatic data processing operations that collect and report data on financial management and procurement in the field and at Headquarters.

Inventions and Contributions Board Actions

The Inventions and Contributions Board, as was indicated in the preceding report, has three functions, two of which are statutory. It considers the petitions of NASA contractors for waiver of rights in inventions made by their employees. It evaluates for possible monetary award scientific and technical contributions received from all sources, whether made by employees of NASA or its contractors, or by persons not affiliated with NASA programs. It makes monetary awards for NASA employee inventions. Hearings are granted on request, as provided in the NASA act, to petitioners for waiver of patent rights and to applicants for awards.

Membership of the Board is shown in appendix E.

Patent Waivers Granted and Denied

During the reporting period, the Board recommended that the petitions for 37 waivers be granted and that 4 be denied. During this period the Administrator of NASA granted 41 waivers and denied 10. (A list of waivers granted and denied is included in app. F.)

Contributions Awards

Under the provisions of the Space Act (1958), the Board evaluates scientific and technical contributions and recommends to the Administrator the amounts and terms of the awards to be made for any found to have significant value in the conduct of aeronautical and space activities. During this period, the Board received 1,497 communications and evaluated 731 contributions. From such evaluations, the Agency granted three awards, as indicated in appendix G.

Invention Awards

Under the provisions of the Incentive Awards Act of 1954, the Board is authorized under its own cognizance to make monetary awards (in amounts not to exceed $5,000), for patentable inventions made by NASA employees. Fifty-three such awards were made during the first half of 1964. (See app. G.)

Organizational Improvements

To further implement the agencywide reorganization of November 1, 1963, NASA continued to make improvements during the first half of 1964.

Executive Secretary Appointed

On February 1, 1964, an Executive Secretary was appointed and assigned the responsibility for maintaining the proper flow of information between general management and other elements of NASA Headquarters. In addition, this official was made responsible for providing secretariat and related services for the Policy Planning Board, for the Technology Utilization Advisory Committee, and generally, for inter- and intra-agency groups or meetings involving general management.

Basic Administrative Processes Documented

In February, the Associate Administrator issued a document defining NASA's basic administrative policies and delineating procedures to be followed by all elements of the agency under the reorganization. The document "NASA Basic Administrative Processes" graphically depicts the procedural flow for the following processes: Annual authorization/appropriation cycle, budget execution, research and development project planning and approval, supporting research and technology planning and approval, facilities planning and approval, procurement, and management reporting and review.

The booklet also defines functional and other basic authorities and responsibilities of Headquarters officials, and outlines the process by which organizational changes are approved.

Kennedy Space Center Functions Realined

Several major organizational improvements were made at the Kennedy Space Center to better aline program management functions with those at other field installations and headquarters.

The Assistant Director for Plans and Projects Management was redesignated Assistant Director for Program Management. This official's systems-oriented organization was realined into an Apollo

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Program Management Office and a Plans and Programs Support Office.

A new position—Assistant Director for Technical Support Operations—was created, and the following functions consolidated and transferred to this official: Launch Support Operations Division, Quality Assurance Division, communications functions, and photographic and technical reports functions.

The Assistant Director for Administration was redesignated Assistant Director for Administrative Management. The Base Operations Division (minus the communications functions) and the NASA Daytona Beach Office were transferred to this official.

These realinements were expected to accomplish certain specific improvements. For one thing, they should simplify relationships in Apollo program management functions with NASA Headquarters, Manned Spacecraft Center, and Marshall Space Flight Center. They should strengthen and separate administrative and technical support functions. They should decrease the span of control by reducing the number of officials reporting directly to the Center Director. And finally, the increased delegations of authority to Assistant Directors permits more decisions to be made at levels closest to operations.

Financial Management

NASA continued to emphasize the importance of sound financial management controls and practices. The use of self-analysis procedures was particularly emphasized in our participation in the President's economy program instituted in November 1963. Specific improvements were made during the 6-month period to assist in the more effective use of program resources.

A recently installed system of reporting manpower use information was consolidated with a previously separate system of reporting financial data derived from the same source. This system integrates the two types of information on a mechanized basis and provides for a simpler and more effective appraisal of in-house program execution against program objectives. The system became operational July 1, 1964.

All NASA installations are now reporting costs incurred on an accrual basis so as to provide management more precise and current cost data for cost-performance analysis.

The format of the monthly financial management data report required of NASA's major contractors was redesigned and the instructions for its preparation and use were clarified and expanded to provide a simpler but more useful reporting system. The revision was approved by the Bureau of the Budget and is now in use.

In order to provide a primary reference so that financial management policy and procedures will be on a consistent agencywide basis, a Financial Management Manual had previously been established and two of the proposed nine volumes issued. During the period, most of the remaining volumes were in the process of development and one was nearly complete.

A standardized financial management reporting system for universities and nonprofit institutions was installed with the approval of the Bureau of the Budget. One immediate benefit resulted from the use of a Grantee Quarterly Cash Requirement Report. On the basis of this report, U.S. Treasury cash in the hands of the grantees will be reduced.

Fiscal Year 1965 Program

Table 1 shows the planned level of effort in research, development, operation, and construction of facilities for fiscal year 1965.

TABLE 1.—*NASA budget estimates, fiscal year 1965*

[In thousands]

Appropriations

	1962 estimates
Research and development:	
Gemini	$308, 400
Apollo	2, 677, 500
Advanced missions	26, 000
Geophysics and astronomy	190, 200
Lunar and planetary exploration	300, 400
Sustaining university program	46, 000
Launch vehicle development	128, 200
Bioscience	31, 000
Meteorological satellites	37, 500
Communication satellites	12, 600
Advanced technological satellites	31, 000
Basic research	21, 000
Space vehicle systems	38, 800
Electronic systems	28, 400
Human factor systems	16, 200
Nuclear-electric systems	48, 100
Nuclear rockets	58, 000
Chemical propulsion	59, 800
Space power	13, 000
Aeronautics	37, 000
Tracking and data acquisition	267, 900
Technology utilization	5, 000
Total, research and development	4, 382, 000
Construction of facilities	281, 000
Administrative operations	641, 000
Total	5, 304, 000

Financial Report, June 30, 1964

Table 2 shows funds obligated and disbursed during fiscal year 1964. Appended is a summary by appropriation showing current availability, obligations against this availability, and unobligated balances as of June 30.

TABLE 2.—*Status of appropriations as of June 30, 1964*

[In thousands]

Appropriations	*Obligations*	*Disbursements*
Research and development:		
Gemini	$419,231	$315,535
Completed missions	*—80	16,662
Apollo	2,224,965	1,856,693
Advanced missions	13,927	8,493
Launch vehicle development	123,257	125,131
Lunar and planetary exploration	199,664	193,394
Geophysics and astronomy	129,820	101,376
Manned space science	2,260	968
Bioscience	21,100	12,013
Unmanned vehicle procurement	112,753	121,206
Meteorological satellites	57,485	56,936
Communications satellites	15,528	21,688
Advanced applications satellites	248	503
Advanced technological satellites	10,754	1,392
Nuclear-electric systems	42,588	42,193
Nuclear rockets	78,669	68,761
Space power	12,536	8,182
Space vehicle systems	42,740	38,891
Electronic systems	24,698	16,610
Human factor systems	11,425	9,016
Chemical propulsion	46,360	56,238
Research program	21,151	17,918
Aeronautics	17,038	13,595
Tracking and data acquisition	148,780	121,142
Facility, training and research grants	35,924	12,192
Technology utilization	3,192	1,377
Operations	8,394	79,748
Reimbursable	51,664	59,504
Total, research and development	3,876,071	3,377,357
Construction of facilities	546,401	439,841
Administrative operations	496,398	417,932
Total	4,918,870	4,235,130

*Represents a net downward adjustment of obligations incurred in prior years.

TABLE 2.—*Status of appropriations as of June 30, 1964*—Continued

[In thousands]

Appropriations summary

	Current availability	*Total obligations*	*Unobligated balance*
Research and development	$4,120,368	$3,876,071	$244,297
Construction of facilities	1,091,192	546,401	544,791
Administrative operations	498,644	496,398	2,246
Total	5,710,204	4,918,870	791,334

Cost Reduction

The NASA Cost Reduction Program was partially implemented in the fall of 1963, and on December 31, 1963, NASA made its first cost reduction report to the President.

The first report established a fiscal year 1964 goal of $81,780,000 and listed the principal methods by which NASA economies were being achieved. (NASA actually effected measurable economies of $128,-783,000 during fiscal year 1964.)

The NASA Cost Reduction Program was formally implemented by NASA Management Manual Issuance 19–1–1, dated May 15, 1964. This issuance, among other things, established a Cost Reduction Board comprised of representatives of NASA's top management and gave the Board a full-time staff. It also instructed officials in charge of headquarters program and staff offices and directors of field installations to assign appropriate personnel to the program and give them sufficient authority to ensure its implementation at the operating levels. Full implementation of this program was assigned highest priority. The internal phase of the program has been implemented, and the contractor participation phase was planned to begin July 1, 1964.

Procurement and Supply Management

During the period, NASA continued to improve its procurement techniques, procedures, and management in order to adequately support all of the Agency's complex programs.

Incentive Contracting

NASA continued its policy of using incentive arrangements appropriate to the circumstances in all possible procurement actions as the most effective means of reducing and controlling costs, assuring timely deliveries, and obtaining the maximum capability and reliability. This practice began in 1962 and has progressed to the point that, by May of 1964, there were 38 incentive-type contracts with a total target value of $353,567,781. Also a number of additional actions with an estimated value of over $163 million were being negotiated.

NASA has profited by the experiences of other agencies in the field of incentive contracting. The Agency has established a particularly valuable liaison with the Department of Defense. However, because NASA's missions, organization, and capabilities are oriented toward a particular kind of research and development, with relatively little opportunity for the application of production techniques, the Agency must discriminate in adapting other agencies' policies and procedures to its own use.

Even so, NASA's plans called for continuing the practice of encouraging incentives in contracts.

For one thing, all levels of the Agency's organization are emphasizing that appropriate incentives will be used in contracts to the fullest extent practicable. For another, NASA officials are examining existing cost-plus-fixed-fee contracts which have potential for conversion to an incentive type and converting as many as possible. For a third, the Agency is continuing the present training program with revised and updated manuals, exploring the feasibility of providing for additional training at advanced levels, and engaging in studies of methods of structuring incentives to produce the best balanced motivations. For still another course of action the Agency is maintaining effective liaison with other agencies, industry, and educational organizations for prompt information on techniques, methods, and approaches that may have applicability. Finally, the Agency is providing field personnel with timely and responsive assistance in their conduct of the incentives program by publishing sound guidance and by having headquarters specialists participate as consultants on specific problems.

Negotiated Overhead Rates

NASA established a procedure for the use of negotiated overhead rates in cost reimbursement-type contracts and subcontracts. (NASA Procurement Regulation, Part 3, Subpart 7). Since many contractors doing business with both NASA and Department of Defense are subject to the negotiated overhead rate procedure with DOD, NASA participates in such negotiations and the rates negotiated are applicable NASA-wide. Because of a shift in procurement predominance, NASA may become the sponsoring agency for such negotiations with certain contractors; in those instances, DOD will participate with NASA in the negotiations.

These coordinated negotiations are beneficial to the Government because a uniform position is presented to the contractor and administrative effort is lessened since, by one negotiation, overhead rates are established and incorporated into all applicable NASA and DOD contracts.

NASA Procurement Regulations

The Agency also completed a program to improve and increase the effectiveness of its procurement regulations. Under this program, all procurement policies, procedures, and instructions were consolidated and published in a separate document entitled the "NASA Procurement Regulation." This regulation was made readily accessible to procurement personnel and placed on sale to the general public through the U.S. Government Printing Office.

Co-location of Procurement Personnel in Program Offices

On February 1, 1964, NASA realined certain responsibilities among its headquarters offices. This resulted in more responsibility for the program offices in certain areas of procurement. These offices assumed a more active role in processing contracts and procurement plans which are referred by the field installations to headquarters for approval.

To ensure that the new system will work efficiently, the Office of Procurement made one or more of its own personnel available to each of the program offices (except the Office of Manned Space Flight, which already had procurement personnel). These people were "co-located"; that is, they were physically located in the program offices. They serve as advisors and staff assistants in procurement matters, performing specific functions of coordinating and reviewing procurement documents for the program director. They also provide close liaison at the working level between the program office and the Office of Procurement.

Requirement for Headquarters Approval of All Letter Contract Issuances

In line with NASA's policy of reducing to a minimum, and eventually eliminating, letter contracts, the Agency established a requirement that all letter contracts, regardless of dollar amount, be authorized by headquarters. This requirement makes certain that letter contracts are issued only when fully justified and facilitates the effort to eliminate letter contracts in the future. (Previously, headquarters authorization to issue a letter contract was required only when it was estimated that the dollar amount of the contract would require headquarters approval.)

Dollar Level of Individual Contracts Requiring Headquarters Approval Raised

Effective March 12, 1964, the dollar level established for individual contracts requiring headquarters approval was raised appreciably for nine installations because of variation in size, function, and procurement staffs of the installations. The highest dollar level was raised from $1 million to $2,500,000, and this applies to six NASA installations. The lowest level is now $200,000, applying to one installation. The revised dollar levels indicate confidence on the part of headquarters that the field installations, through their own experience and headquarters guidance, are increasingly able to handle large and complex procurements.

NASA Policy and Procedures for Use of Contracts for Nonpersonal Services

This new regulation was issued to set forth NASA policy with respect to the use of contracts for nonpersonal services and the principles and requirements to be followed by all NASA installations. This regulation does not apply to contracts for personal services or to the hiring of consultants and experts.

Two-Step Formal Advertising

NASA issued a new regulation authorizing the use of two-step formal advertising. This is a method of procurement which is conducted in two phases. The first phase results in submission and evaluation of technical proposals, without pricing. The second phase follows ordinary formal advertising procedures, except that each bidder bids upon his own proposal, which has previously been determined to be acceptable. The use of these procedures must be approved in advance at a higher level than the contracting officer.

Labor Regulations

These regulations were revised on a priority basis in order to reflect changes in Department of Labor Regulations concerning wage rate determinations (29 CFR pts. 1, 3, and 5, as published in the Federal Register of Jan. 4, 1964, 29 F.R. 95–104). Additional revisions to the NASA procurement regulation, designed to further implement the revised Department of Labor Regulations, are to be issued when developed.

Safety and Health

This new regulation was developed to set forth the policy, responsibility, and requirements for contract provisions relating to NASA's safety and health program.

Summary of Contract Awards

NASA's procurements for the last 6 months of fiscal year 1964 totaled $2,643 million. This is 37 percent more than was awarded during the corresponding period of fiscal year 1963.

Approximately 78 percent of the net dollar value was placed directly with business firms, 3 percent with educational and other nonprofit institution organizations, 4 percent with the California Institute of Technology for operation of the Jet Propulsion Laboratory, and 15 percent with or through other Government agencies.

Contracts Awarded to Private Industry.—Ninety percent of the dollar value of procurement requests placed by NASA with other Government agencies resulted in contracts with industry awarded by such other agencies on behalf of NASA. Also, about 73 percent of the funds placed by NASA under the Jet Propulsion Laboratory contract resulted in subcontracts or purchases with business firms. In short, about 94 percent of NASA's procurement dollars was contracted to private industry.

Sixty-two percent of the total direct awards to business represented competitive procurements, either through formal advertising or competitive negotiation. An additional 12 percent represented actions on follow-on contracts placed with companies that had previously been selected on a competitive basis to perform the research and development on the applicable project. In these instances, selection of another source would have resulted in additional cost to the Government by reason of duplicate preparation and investment. The remaining 26 percent included contracts for facilities required at contractors' plants for performance of their NASA research and development effort, contracts arising from unsolicited proposals offering new ideas and concepts, contracts employing unique capabilities, and procurements of sole-source items.

Reflecting the fact that NASA's procurements are primarily for research and development, 76 percent of the awards to business was placed under cost-plus-fixed-fee contracts. However, in line with NASA's policy to include incentive provisions in its contracts, whereever appropriate, 10 percent of the awards represented incentive-type contracts. Thirteen percent of the awards were placed under firm fixed-price contracts.

Small Business Participation.—Small business firms received 7 percent of NASA's direct awards to business. Excluding the 20 largest awards which were for major systems and hardware requiring resources not generally within the capability of small business on a prime contract basis, small business received 18 percent of the total awards to business.

In addition to the direct awards to small business, approximately 17 percent of NASA's awards to large business are being subcontracted to small business.

Geographical Distribution of Prime Contracts.—Within the United States, NASA's prime contract awards were distributed among 49 States and the District of Columbia. Business firms in 44 States, educational institutions in 49 States, and other nonprofit institutions in 24 States participated in the awards. Eight percent of the awards were placed in labor surplus areas located in 24 States.

Subcontracting.—Subcontracting effected a further distribution of the prime contract awards. Twelve of NASA's major prime contracts located in 9 States reported that their larger subcontract awards on NASA effort had gone to 1,400 subcontractors in 45 States and that 77 percent of these subcontract dollars had crossed State lines.

Major Contract Awards.—Among the major research and development aggregate contract awards by NASA during the period were the following:

(1) North American Aviation, Inc., Downey, Calif., NAS9-150. Design, develop, and test three-man earth to moon and return Apollo spacecraft. Awarded $545 million; cumulative awards $870 million.

(2) McDonnell Aircraft Corp., St. Louis, Mo., NAS9-170. Design and develop two-man Gemini spacecraft. Awarded $268 million; cumulative awards $491 million.

(3) The Boeing Co., Huntsville, Ala., NAS8-5608. Design, develop, and fabricate the S-IC Stage of the Saturn V vehicle and construct facilities in support of the S-IC stage. Awarded $160 million; cumulative awards $227 million.

(4) Douglas Aircraft Co., Inc., Santa Monica, Calif., NAS7-101. Design, develop, and fabricate the S-IVB stage of the Saturn V vehicle and associated ground support equipment. Awarded $140 million; cumulative awards $177 million.

(5) Grumman Aircraft Engineering Corp., Bethpage, N.Y., NAS9-1100. Lunar excursion module development for the Apollo Program. Awarded $135 million; cumulative awards $150 million.

(6) North American Aviation, Inc., Downey, Calif., NAS7-200. Design, develop, fabricate, and test the S-II stage of the Saturn V vehicle. Awarded $123 million; cumulative awards $217 million.

(7) General Dynamics Corp., San Diego, Calif., NAS3-3232. Develop, fabricate, and deliver Centaur vehicles and support

equipment. Awarded $114 million; cumulative awards $168 million.

(8) General Electric Co., Daytona Beach, Fla., NASw–410. Overall integration, checkout, and reliability of Apollo space vehicle system. Awarded $97 million; cumulative awards $122 million.

(9) Chrysler Corp., New Orleans, La., NAS8–4016. Fabricate, assemble, checkout, and static test Saturn S–1 stage. Provide product improvement program and spare parts support. Modify areas of Michoud Plant assigned to contractor. Awarded $90 million; cumulative awards $154 million.

(10) Aerojet General Corp., Azusa, Calif., SNP–1. Design, develop, and produce a nuclear powered rocket engine (NERVA). Awarded $82 million; cumulative awards $194 million.

(11) Douglas Aircraft Co., Santa Monica, Calif., NAS7–1. Design, develop, and fabricate Saturn S–IV stage and associated ground support equipment for the Saturn S–I vehicle. Awarded $82 million; cumulative awards $218 million.

(12) North American Aviation, Inc., Canoga Park, Calif., NASw–16. Develop and fabricate 1,500,000-pound-thrust F–1 rocket engine. Awarded $63 million; cumulative awards $229 million.

(13) North American Aviation, Inc., Canoga Park, Calif., NAS8–19. Develop 200,000-pound-thrust J–2 rocket engine. Awarded $50 million; cumulative $133 million.

(14) North American Aviation, Inc., Canoga Park, Calif., NAS8–5604. Procure 1,500,000-pound-thrust F–1 rocket engines with supporting services and hardware. Awarded $40 million; cumulative awards $57 million.

(15) General Motors Corp., Milwaukee, Wis., NAS9–497. Guidance computer subsystem for Apollo command service module. Awarded $39 million; cumulative awards $48 million.

(16) North American Aviation, Inc., Canoga Park, Calif., NAS8–5603. Procure 200,000-pound-thrust J–2 rocket engines with supporting services and hardware. Awarded $34 million; cumulative awards $52 million.

(17) Philco Corp., Palo Alto, Calif., NAS9–1261. Equipment and construction of facilities for the Integrated Mission Control Center. Awarded $33 million; cumulative awards $43 million.

(18) Aerojet General Corp., Sacramento, Calif., NAS3–2555. Design, develop, and test 1,500,000-pound-thrust M–1 rocket engine. Awarded $23 million; cumulative awards $67 million.

(19) Raytheon Co., Bedford, Mass., NAS9-498. Guidance computer subsystem for Apollo spacecraft. Awarded $21 million; cumulative awards $27 million.

(20) Grumman Aircraft Engineering Corp., Bethpage, N.Y., NAS5-814. Design and develop S-18, S-58 orbiting astronomical observatories. Awarded $21 million; cumulative awards $85 million.

Major Contractors.—The 25 contractors receiving the largest direct awards (net value) during fiscal year 1964 are as follows:

Aerojet General Corp.
*Sacramento, Calif.
Bendix Corp.
*Owings Mills, Md.
Blount Bros. Construction Co.
*Montgomery, Ala.
Boeing Co.
*Huntsville, Ala.
Brown Engineering Co., Inc.
*Huntsville, Ala.
Chrysler Corp.
*New Orleans, La.
Control Data Corp.
*Minneapolis, Minn.
Douglas Aircraft Co., Inc.
*Santa Monica, Calif.
General Dynamics Corp.
*San Diego, Calif.
General Electric Co.
*Daytona Beach, Fla.
General Motors Corp.
*Milwaukee, Wis.
Grumman Aircraft Engineering Corp.
Bethpage, N.Y.
Hayes International Corp.
*Birmingham, Ala.
Hughes Aircraft Co.
*Culver City, Calif.
International Business Machines Corp.
*Rockville, Md.
Ling-Temco-Vought, Inc.
*Dallas, Tex.
Lockheed Aircraft Corp.
*Sunnyvale, Calif.
McDonnell Aircraft Corp.
St. Louis, Mo.
North American Aviation, Inc.
*Downey, Calif.
Philco Corp.
*Palo Alto, Calif.
Radio Corp. of America
Princeton, N.J.
Raytheon Co.
*Bedford, Mass.
Thompson-Ramo-Wooldridge, Inc.
*Redondo Beach, Calif.
Union Carbide Corp.
*Frontana, Calif.
United Aircraft Corp.
*West Palm Beach, Fla.

*Awards during period involve more than 1 contractor address.

Technology Utilization

During the reporting period, this NASA program placed prime emphasis on improving the flow of technical information to potential users. NASA continued a solid program of pilot projects to encourage the transfer of space research information on a regional basis.

The results of the first year's operation at the Aerospace Research Applications Center at Indiana University were positive and encouraging. The utilization of the service by the members was increasing rapidly, and the number of participating companies growing steadily. NASA support was continued for the second year.

In addition to efforts previously initiated at Wayne State University and the University of Maryland, similar regional information centers were being supported at the University of Pittsburgh and the North Carolina Research Triangle. In all of these centers the cooperation and support of regional industry was being obtained. NASA's role was one of encouraging and assisting in testing the feasibility of the local approach. A university in most cases is the primary agency, and the ultimate goal is self-sufficiency of the centers.

During the report period, the issuance of brief technical bulletins called "Tech Briefs" was initiated to acquaint industry with promising innovations identified by NASA installations and NASA contractors. By passing these innovations on to industry as quickly as possible, technology relevant to particular needs can be quickly utilized. The Tech Briefs are distributed to a special mailing list consisting of companies and individuals who have requested all technology utilization publications, as well as to the trade press and news media.

When a sufficient quantity of these 1–2-page descriptions has been published, they will be indexed, bound, and placed on sale through the Department of Commerce, Office of Technical Services. As of June 30, 1964, 124 Tech Briefs had been published and disseminated. They cover such diverse subjects as the uses of refractory ceramics, valve design, and cutting torches designed from hypodermic needles.

Cooperation with other Federal agencies was continued and expanded. In continuation of the Technology Utilization Division's attempts to assure a full flow of scientific and technical information from space research to smaller businesses, addressees of the Small Business Administration's "facility inventory" list received notices on selected Technology Utilization publications. About 8,000 requests have been received for one or more publications.

Close cooperation was also established with the Food and Drug Administration (FDA) and the Bureau of Public Roads (BPR) on matters related to their areas of responsibility. The Food and Drug Administration showed interest in a device adapted from NASA-developed equipment which may permit monitoring of heart functions in drugged chicken embryos. The BPR was cosponsoring a highway safety film which deals with the tire hydroplaning phenomenon, first identified and studied in detail at Langley Research Center.

Appendix A

MEMBERSHIPS OF CONGRESSIONAL COMMITTEES ON AERONAUTICS AND SPACE

(*Jan. 1–June 30, 1964*)

Senate Committee on Aeronautical and Space Sciences

CLINTON P. ANDERSON, New Mexico, *Chairman*
RICHARD B. RUSSELL, Georgia
WARREN G. MAGNUSON, Washington
STUART SYMINGTON, Missouri
JOHN STENNIS, Mississippi
STEPHEN M. YOUNG, Ohio
THOMAS J. DODD, Connecticut
HOWARD W. CANNON, Nevada
SPESSARD L. HOLLAND, Florida
J. HOWARD EDMONDSON, Oklahoma
MARGARET CHASE SMITH, Maine
CLIFFORD P. CASE, New Jersey
BOURKE B. HICKENLOOPER, Iowa
CARL T. CURTIS, Nebraska
KENNETH B. KEATING, New York

House Committee on Science and Astronautics

GEORGE P. MILLER, California, *Chairman*
OLIN E. TEAGUE, Texas
JOSEPH E. KARTH, Minnesota
KEN HECHLER, West Virginia
EMILIO Q. DADDARIO, Connecticut
J. EDWARD ROUSH, Indiana
THOMAS G. MORRIS, New Mexico
BOB CASEY, Texas
WILLIAM J. RANDALL, Missouri
JOHN W. DAVIS, Georgia
WILLIAM F. RYAN, New York
THOMAS N. DOWNING, Virginia
JOE D. WAGGONNER, JR., Louisiana
EDWARD J. PATTEN, New Jersey
RICHARD H. FULTON, Tennessee
DON FUQUA, Florida
NEIL STAEBLER, Michigan
CARL ALBERT, Oklahoma
JOSEPH W. MARTIN, JR., Massachusetts
JAMES G. FULTON, Pennsylvania
J. EDGAR CHENOWETH, Colorado
WILLIAM K. VAN PELT, Wisconsin
R. WALTER RIEHLMAN, New York
CHARLES A. MOSHER, Ohio
RICHARD L. ROUDEBUSH, Indiana
ALPHONZO BELL, California
THOMAS M. PELLY, Washington
DONALD RUMSFELD, Illinois
JAMES D. WEAVER, Pennsylvania
EDWARD J. GURNEY, Florida
JOHN W. WYDLER, New York

Appendix B

Membership of the National Aeronautics and Space Council

(Jan. 1–June 30, 1964)

(Vacant) *Chairman*
Vice President of the United States

DEAN RUSK
Secretary of State

ROBERT S. MCNAMARA
Secretary of Defense

JAMES E. WEBB, *Administrator*
National Aeronautics and Space Administration

GLENN T. SEABORG, *Chairman*
Atomic Energy Commission

Executive Secretary
EDWARD C. WELSH

Appendix C

Current Official Mailing Addresses for Field Installations

(June 30, 1964)

Installation and telephone number	Official	Address
Ames Research Center; YO 8-9411	Dr. Smith J. DeFrance, Director	Moffett Field, Calif.
Flight Research Center; 258-3311	Mr. Paul Bikle, Director	Post Office Box 273, Edwards, Calif.
Goddard Space Flight Center; 474-9000	Dr. H. J. Goett, Director	Greenbelt, Md.
Goddard Institute for Space Studies; UN 6-3600.	Dr. Robert Jastrow, Director	475 Riverside Dr., New York 27, N.Y.
Jet Propulsion Laboratory; SY 0-6811	Dr. W. H. Pickering, Director	4800 Oak Grove Dr., Pasadena 3, Calif.
John F. Kennedy Space Center; UL 3-6998.	Dr. Kurt Debus, Director	Cocoa Beach, Fla.
Lewis Research Center; 433-4000	Dr. Abe Silverstein, Director	21000 Brookpark Rd., Cleveland 35, Ohio.
Manned Spacecraft Center; WA 8-2811	Dr. R. R. Gilruth, Director	Houston 1, Tex.
George C. Marshall Space Flight Center; 877-1000.	Dr. Wernher von Braun, Director	Huntsville, Ala.
Michoud Operations; 521-3311	Mr. George Constan, Manager	Post Office Box 26078, New Orleans 26, La.
Mississippi Test Operations; 467-5466	Mr. William C. Fortune, Manager.	Bay St. Louis, Miss.
North Eastern Office; 491-1500	Mr. F. W. Phillips, Director	30 Memorial Dr., Cambridge 42, Mass.
Pacific Launch Operations Office; RE 4-4311.	Mr. William H. Evans, Director	Post Office Box 425, Lompoc, Calif.
Plum Brook Station; MA 5-1123	Mr. Alan D. Johnson, Director	Sandusky, Ohio.
Wallops Station; VA 4-3411	Mr. Robert Krieger, Director	Wallops Island, Va.
Western Operations Office; EX 3-9641	Mr. R. W. Kamm, Director	150 Pico Blvd., Santa Monica, Calif.

Appendix D

Principal Officials of NASA at Washington Headquarters

(*June 30, 1964*)

James E. Webb	Administrator
Dr. Hugh L. Dryden	Deputy Administrator
Dr. George L. Simpson, Jr.	Assistant Deputy Administrator, and Assistant Administrator, Office of Technology Utilization and Policy Planning
Walter D. Sohier	General Counsel
Arnold W. Frutkin	Assistant Administrator, Office of International Programs
Richard L. Callaghan	Assistant Administrator, Office of Legislative Affairs
Julian Scheer	Assistant Administrator, Office of Public Affairs
Dr. Robert C. Seamans, Jr	Associate Administrator
John D. Young	Deputy Associate Administrator, Office of Administration
Earl D. Hilburn	Deputy Associate Administrator, Office of Industry Affairs
DeMarquis D. Wyatt	Deputy Associate Administrator, Office of Programing
Adm. W. Fred Boone, USN, (Ret.)	Deputy Associate Administrator, Office of Defense Affairs
Edmond C. Buckley	Director, Office of Tracking and Data Acquisition
Dr. Raymond L. Bisplinghoff	Associate Administrator, Office of Advanced Research and Technology
Dr. George E. Mueller	Associate Administrator, Office of Manned Space Flight
Dr. Homer E. Newell	Associate Administrator, Office of Space Science and Applications

(Telephone information: WO 3–7101)

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Appendix E

Membership of Inventions and Contributions Board, NASA

(*June 30, 1964*)

Chairman	ROBERT E. LITTELL
Vice Chairman	PAUL G. DEMBLING
Executive Secretary	JAMES A. HOOTMAN
Members	J. ALLEN CROCKER
	C. GUY FERGUSON
	GERALD D. O'BRIEN
	JOHN B. PARKINSON

Appendix F

Patent Waivers Granted and Denied by NASA Upon Recommendation of the Agency's Inventions and Contributions Board

(Jan. 1–June 30, 1964)

Invention	Petitioner	Action on petition
Magnetic-Flux Pump	California Institute of Technology	Granted Jan. 13, 1964.
Magnetic-Field-Trapping Device	do	Do.
Magnetic-Flux Pump	do	Do.
Continuous Magnetic-Flux Pump	do	Do.
Cryogenic Flow Meter Calibrator	North American Aviation, Inc.	Denial Jan. 20, 1964.
Arithmetic Divider Circuit	International Business Machines, Corp.	Granted Jan. 20, 1964.
Solid State Camera Apparatus and System	Electro-Radiation, Inc.	Do.
Radiant Heat Attenuator	North American Aviation, Inc.	Denial Jan. 24, 1964.
Paraglider Deployment	do	Denial Jan. 30, 1964.
Ferroelectric Bolometer	Ingras et al of Harvard College	Granted Feb. 3, 1964.
Keyed Connector for Plugs and Sockets	McDonnell Aircraft Corporation	Do.
At Assembly Tube Cleaning Tool	do	Do.
At Assembly Tube Cut Off Tool	do	Do.
Tube End Deburring Tool	do	Do.
Two-Way Solenoid Valve	North American Aviation, Inc.	Granted Feb. 5, 1964.
Swash-Plate Gimbal Bearing	do	Do.
High Speed Differential Sampler and Amplifier.	International Business Machines, Corp.	Granted Feb. 7, 1964.
Microwave Frequency Doubler	Hughes Aircraft Co.	Do.
Fastener-Honeycomb Non-Crush Installation.	North American Aviation, Inc.	Do.
Airborne Sampled Data Reduction	International Business Machines, Corp.	Granted Feb. 14, 1964.
Temperature Transducer	Ball Brothers Research Corp.	Do.
Porous Body with Imperviously Sealed Outer Surface and Method of Making Same.	Kulite Tungsten Co.	Do.
Analog-to-Digital Converter	California Institute of Technology	Granted Feb. 20, 1964.
Seismometer	do	Do.
Pressure Responsive Ring Valve	North American Aviation, Inc.	Denial Feb. 20, 1964.
Improved Ionization Vacuum Gage	California Institute of Technology	Denial Mar. 2, 1964.
Hypergolic Pressurization System	North American Aviation, Inc.	Do.
Composition of Matter and Method of Making Same.	Space Technology Laboratories, Inc.	Granted Mar. 2, 1964.
Transient-Free Phase-Lock Loop Bandwidth Switching.	do	Denial Mar. 9, 1964.
An Adapter Filter for a Phase Lock Loop	do	Do.
Solar Cell Mounting	do	Denial Mar. 12, 1964.
Low Pressure Relief Valve	North American Aviation, Inc.	Granted Mar. 12, 1964.
Ion Gage	Hughes Aircraft Co.	Granted Mar. 13, 1964.
Dual-Wound Helix	Space Technology Laboratories, Inc.	Do.

Patent Waivers Granted and Denied by NASA Upon Recommendation of the Agency's Inventions and Contributions Board—Continued

(*Jan. 1–June 30, 1964*)

Invention	Petitioner	Action on petition
Film Reader	Chicago Aerial Industries	Granted Apr. 13, 1964.
Developer-Processor	do	Do.
Improvements in Laminated Magnetic Memories for use with Integrated Semiconductor Circuit Systems.	Radio Corp. of America	Granted Apr. 20, 1964.
Determination of Composition of Liquid Hydrogen.	North American Aviation, Inc	Granted May 6, 1964.
Fecal Canister Assembly and Fecal Collection Bag.	do	Do.
Exhaust Gas Cooled Nozzle Extension	do	Denial May 11, 1964.
Wet Wall Insulation for Cryogenic Fluids	Douglas Aircraft Corp	Granted May 11, 1964.
Drill	do	Granted May 12, 1964.
Method of Heat Treating Age Hardenable Alloys.	North American Aviation, Inc	Do.
Ceramic-to-Metal Seal	Eitel-McCullough, Inc	Granted May 22, 1964.
Method for the Preparation of Inorganic Single Crystal and Polycrystal Electronic Material.	Monsanto Chemical Co	Do.
Solar Cell Module Assembly Jig	Space Technology Laboratories, Inc.	Granted May 22, 1964.
Regenerative Fuel Cell	Electro-Optical Systems, Inc	Granted June 10, 1964
Method of Fabricating Fine Grids	do	Do.
A Porous Metal Structure and Process Therefor.	do	Do.
Brazed Fluid System Stub Union Removal Tool.	McDonnell Aircraft Corp	Do.
Universal Restrainer and Joint	North American Aviation, Inc	Do.

Appendix G

Scientific and Technical Contributions Recognized by the Agency's Inventions and Contributions Board

(*Jan. 1–June 30, 1964*)

Awards Granted Under Provisions of Section 306 of the Space Act of 1958

Contribution	Inventor(s)	Employer
Spin adjusting mechanism	Robert C. Baumann and Leopold Winkler.	Goddard Space Flight Center.
Trajectory-correction propulsion system.	William W. Smith	Jet Propulsion Laboratory (California Institute of Technology).
	Bruce W. Schmitz	Rocket Research Corp.
Solar cell for radiation environment	William R. Cherry	Goddard Space Flight Center.
	Joseph Mandelkorn	Lewis Research Center.

Awards Granted NASA Employees Under Provisions of the Incentive Awards Act of 1954

Invention	Inventor(s)	Employer
Externally Pressurized Fluid Bearing.	Emmett L. Martz	Marshall Space Flight Center.
Heat Shield	Richard B. Erb and Kenneth C. Weston.	Manned Spacecraft Center.
Wide Range Linear Fluxgate Magnetometer	James P. Heppner and Harold R. Boroson.	Goddard Space Flight Center.
Self-Calibrating Displacement Transducer.	Royce L. McKinney	Langley Research Center.
Bi-Carrier Demodulation with Modulation Separation.	James R. Currie	Marshall Space Flight Center.
Reduced Gravity Simulator	Donald E. Hewes and Amos A. Spady, Jr.	Langley Research Center.
Electrocardiogram (EKG) Simulator.	Gary J. Woods	Manned Spacecraft Center.
Automatic Spacing Control System.	Herschel M. Nance	Marshall Space Flight Center.
Method and Apparatus for Making Two-Sided Printed Circuit Boards.	Warren J. Price	Langley Research Center.
Continuously Indicating Calorimeter.	Robert D. Ross	Langley Research Center.
Pressure Balance	Albert Schuler	Marshall Space Flight Center.
High-Efficiency Multivibrator	Robert M. Munoz	Ames Research Center.
Minimum-Induced-Drag Airfoil Body.	Clarence D. Cone, Jr.	Langley Research Center.

Awards Granted NASA Employees Under Provisions of the Incentive Awards Act of 1954—Continued

Contribution	Inventor(s)	Employer
Normal Shock Positioning Apparatus.	George Vasu	Lewis Research Center.
Practical Hot Wire Liquid Level Detector for Cryogenic Fluids.	William A. Olsen	Lewis Research Center.
Foldable Conduit	Laurence W. Gertsma and James H. Dunn.	Lewis Research Center.
Highly Flexible Cellular Structure.	Robert J. Carmody	Marshall Space Flight Center.
Bilateral Energy Transfer System.	Klaus Juergensen	Marshall Space Flight Center.
Force Measuring Instrument	Lester Katz and Jack J. Nichols	Marshall Space Flight Center.
Metallic Film Lubricant	Donald H. Buckley and Robert L. Johnson	Lewis Research Center.
Thin Window, Drifted Silicon, Charged Particle Detector.	Theodore E. Fessler, John S. Vincent, and Albert B. Smith.	Lewis Research Center.
Annular Rocket Motor	James F. Connors	Lewis Research Center.
Apparatus for Absorbing and Measuring Power.	Robert Y. Wong, William J. Nusbaum, and Donald E. Holeski.	Lewis Research Center.
Self-Latching Handle	Benjamin M. Saunders	Marshall Space Flight Center.
Test Unit Free-Flight Suspension System.	Wilmer H. Reed, III	Langley Research Center.
Dynamic Precession Damper for Spin-Stabilized Vehicles.	Howell D. Garner and Henry J. E. Reid, Jr.	Langley Research Center.
Gas Actuated Bolt Disconnect	William H. Kinard	Langley Research Center.
Electro-Thermal Rockets Having Improved Heat Exchangers.	Paul F. Brinich and John R. Jack	Lewis Research Center.
Manned Space Vehicle Configuration.	Alan B. Kehlet, Dennis F. Hasson, and William W. Petynia.	Langley Research Center/Goddard Space Flight Center.
Separator	Franklin W. Booth	Langley Research Center.
Non-Magnetic Battery Case	Thomas Hennigan	Goddard Space Flight Center.
Heat Curing of Thermosetting Plastic Film Adhesive.	Robert J. Carmody	Marshall Space Flight Center.
Black-Body Furnace	J. Robert Branstetter and Allen J. Metzler.	Lewis Research Center.
Aircraft Wheel Spray Drag Alleviator.	Walter B. Horne	Langley Research Center.
Impurity-Type Semi-Conductor Electrical Contacts.	Jackson C. Horton and Harry M. King.	Marshall Space Flight Center.
Prevention of Pressure Build-Up in Electrochemical Cells.	Thomas J. Hennigan, Paul C. Donnelly, and Charles F. Palandati, Jr.	Goddard Space Flight Center.
Unfired-Ceramic Flame-Resistant Insulation.	Vaughn F. Seitzinger	Marshall Space Flight Center.
Apparatus and Low Viscosity Magnetic Fluid Obtained by the Colloidal Suspension of Magnetic Particles.	Solomon S. Papell	Lewis Research Center.
Electrostatic Ion Engine Having Permanent Magnetic Circuit.	Paul D. Reader and Harold R. Kaufman.	Lewis Research Center.
Gas Analyzer for Bi-Gaseous Mixtures.	Leonard T. Melfi, Jr., George M. Wood, Jr., Paul R. Yeager.	Langley Research Center.
Frequency Converter Re-Entrant Amplifier.	Walter K. Allen	Goddard Space Flight Center.
Vehicle Flexible Wing Configurations.	Francis M. Rogallo	Langley Research Center.
Instrument for Use in Performing a Controlled Valsalva Maneuver.	Maxwell M. Lippitt, Jr., and John H. Reed, Jr.	Manned Spacecraft Center.
Tape Cartridge	Kenneth W. Stark, and William A. Burton.	Goddard Space Flight Center.

Awards Granted NASA Employees Under Provisions of the Incentive Awards Act of 1954—Continued

Contribution	Inventor(s)	Employer
Tape Transport Mechanism	Kenneth W. Stark	Goddard Space Flight Center.
Injector Assembly for Liquid Fueled Rocket Engines.	William J. D. Escher	Marshall Space Flight Center.
Lunar Penetrometer	George W. Brooks, John L. McCarty, and Alfred G. Beswick.	Langley Research Center.
Reinforced Metallic Composite Material.	David L. McDanels, Robert W. Jech, John W. Weeton, and Donald W. Petrasek.	Lewis Research Center.
Gas Lubricant Compositions	Donald H. Buckley and Robert L. Johnson.	Lewis Research Center.
A Densitometer	Charles E. Miller and Robert B. Jacobs.	Lewis Research Center.
Multiple Ionization Gage Control System.	Robert C. Finke	Lewis Research Center.
Liquid Storage Tank Venting Device for Zero Gravity Environment.	Solomon S. Papell and Robert W. Graham.	Lewis Research Center.
Metal Forming Die	John H. Chattin, John C. Laughlin, Johnny E. Haystrick, and Ray A. Leidy.	Lewis Research Center.

Appendix H

Educational Publications and Motion Pictures

(January 1–June 30, 1964)

The following Educational Publications are available to the public upon request without charge, from the Division of Educational Programs and Services, Educational Publications Distribution Center, AFEE–1, National Aeronautics and Space Administration, Washington, D.C., 20546.

1. *Advanced Research—Key to the Future.*—A description for educators and the general public of NASA's fundamental research programs.

2. *NASA Facts—TIROS.*—A nontechnical description of the TIROS weather satellite system.

3. *TIROS Picture Set.*—A compilation of photographs from the TIROS program.

4. *NASA Photography from Five Years of Space.*—A compilation of outstanding photographs of NASA's space activities.

5. *NASA Installations.*—A booklet describing NASA facilities throughout the Nation.

6. *Teaching to Meet the Challenge of the Space Age.*—A handbook of aerospace education for elementary school teachers.

7. *What Makes a Rocket Go?*—A teacher's film guide for use with the motion picture of the same title.

Reprints from periodicals include:

1. *Why Land on the Moon?*—by Dr. Homer E. Newell, Associate Administrator for Space Science and Applications, NASA, and Dr. Robert Jastrow, Director of NASA's Goddard Institute for Space Studies, from "Atlantic Monthly."

2. *Footprints on the Moon.*—by Dr. Hugh L. Dryden, NASA Deputy Administrator, from "National Geographic Magazine."

3. *Economic Impact of the Space Program.*—by James E. Webb, NASA Administrator, from "Business Horizons."

4. *Forty Miles of Information Every Day from Space.*—by Lawrence Lessing. Discusses new information about space and the earth gained since the opening of the space age and some future plans for space exploration; from "Fortune."

5. "Aerospace," September–October 1963 issue, by the Aerospace Industries Association of America, Inc. The issue features NASA activities.

Updated editions of previously issued publications include:

1. *NASA Facts—Project Syncom.*
2. *X–15 Research at the Edge of Space.*
3. *Space—The New Frontier.*
4. *Manned Space Flight Team.*
5. *Historical Origins of the National Aeronautics and Space Administration.*
6. *Educational Publications.*

The following motion pictures when released will be available to the public upon request without charge, other than return mailing and insurance costs, from the National Aeronautics and Space Administration, Office of Educational Programs and Services, Educational Audio-Visual Branch, Washington, D.C., 20546. Films presently available are listed in a brochure supplied from the above address. These three motion pictures were in final production stages:

- "Electric Propulsion."
- "The World Was There" (NASA-news media cooperation).
- "The Shape of Things to Come" (NASA advanced research).

The following motion pictures were in the early stages of planning or production:

- "NASA's Technology Utilization Program."
- "Historical Origins of NASA."
- "The Biosatellite Program."
- "The Development of the X-15."
- "Space Navigation."
- "Adventures in Research." (Group of 10 separate films.)

Appendix I

Technical Publications

The following selected special publications, issued by NASA's Division of Scientific and Technical Information, are sold by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, or, if so indicated, by the Office of Technical Services, U.S. Department of Commerce, Washington, D.C., 20230, at the prices listed.

Advanced Bearing Technology (NASA SP–38).*—An exposition of the fundamentals of friction and wear, fluid film bearings, and rolling-element bearings, plus demonstrations of how fundamental principles can be applied to the solution of unique and advanced bearing problems. Authors, Edmond E. Bisson and William J. Anderson, Lewis Research Center. 511 pp., $1.75.

Selected Listing of NASA Scientific and Technical Reports for 1963 (NASA SP–7005).*—A comprehensive listing, complete with abstracts and indexes, of the Agency's reports during the year. 230 pp., $3.50.

Conference on the Law of Space and of Satellite Communications (NASA SP–44).*—Proceedings of a conference organized by Northwestern University School of Law, May 1–2, 1963, as part of the Third National Conference on the Peaceful Uses of Space. 205 pp., $1.50.

Space-Cabin Atmospheres: Part II, Fire and Blast Hazards (NASA SP–48).*—A summary of the open literature on the subject, intended primarily for biomedical scientists and design engineers. 119 pp., $1.00.

Meteorological Observations Above 30 Kilometers (NASA SP–49).*—Three papers on meteorological rockets, network data, and rocket soundings comprising one session of a conference on Meteorological support for Aerospace Testing and Operation, July 11–12, 1963. 57 pp., $0.40.

Space Batteries (NASA SP–5004).*—Descriptions of three sealed battery systems for spacecraft, including discussion of a mechanism of information exchange whereby current test data can be shared among space contractors. 53 pp., $0.25.

The Measurement of Blood Pressure in the Human Body (NASA SP–5006).*—A state-of-the-art summary prepared from the open literature for nonmedical scientists and engineers. 34 pp., $0.30.

Project Mercury Summary Including Results of the Fourth Manned Orbital Flight, May 15 and 16, 1963 (NASA SP–45).—A review of the planning, preparation, experiences, and results of the first U.S. manned space flight program, with particular attention to the results of the final, 34-hour mission of L. Gordon Cooper. 444 pp., $2.75.

Project Mercury—a Chronology (NASA SP–4001).—A listing of major events in the first U.S. manned space flight program from preliminary discussions of

*Released during this report period.

earth satellite vehicles through Astronaut Cooper's 22-orbit flight, May 1963. 238 pp., $1.50.

Third United States Manned Orbital Space Flight (NASA SP-12).—Results of the MA-8 flight by Astronaut Walter Schirra, October 1962, including spacecraft and launch-vehicle performance, mission operations, aeromedical analysis, pilot performance, and pilot's flight report. 120 pp., 70 cents.

Second United States Manned Orbital Space Flight (NASA SP-6).—Results of the MA-7 flight by Astronaut M. Scott Carpenter, May 1962, including spacecraft and launch vehicle performance, Mercury network performance, mission operations, space science report, aeromedical studies, pilot performance, and pilot's flight report. 107 pp., 65 cents.

Results of the Project Mercury Ballistic and Orbital Chimpanzee Flights (NASA SP-39).—An account of the suborbital and orbital flights conducted in 1961 with chimpanzees as subjects in preparation for the first U.S. manned space flights. 71 pp., 45 cents.

Space, Science, and Urban Life (NASA SP-37).—Proceedings of a conference, March 1963, on the applicability of the national space program, and the knowledge resulting from aerospace research, to the problems of urban growth. 254 pp., $1.75.

The Observatory Generation of Satellites (NASA SP-30).—Discussion of the missions and engineering designs of the Orbiting Geophysical Observatories, the Advanced Orbiting Solar Observatory, and the Orbiting Astronomical Observatory. 62 pp., 50 cents.

Ariel I: The First International Satellite (NASA SP-43).—Project summary of the satellite launched April 26, 1962, in a cooperative effort by the United Kingdom and the United States. 76 pp., 70 cents.

U.S. Standard Atmosphere, 1962.—Updated tables of atmospheric parameters to 700 kilometers, incorporating results of rocket and satellite research through mid-1962. 278 pp., in hard covers, $3.50.

Short Glossary of Space Terms (NASA SP-1).—Brief definitions of technical terms frequently used by space technologists. 57 pp., 25 cents.

Selected Welding Techniques (NASA SP-5003).—Descriptions and illustrations of tools and methods developed by NASA, and of potential value to industry, for welding aluminum sheet and plate. 25 pp., 30 cents.

NASA-Industry Program Plans Conference, 1963 (NASA SP-29).—Statements describing NASA's organization, present plans, and possible future projects presented for the information of industrial management as a partner in the national space program. 231 pp., $1.25.

Conference on Space-Age Planning (NASA SP-40).—Proceedings of the general sessions of the Third National Conference on the Peaceful Uses of Space, May 1963. 301 pp., $2.

Proceedings of the Second National Conference on the Peaceful Uses of Space (NASA SP-8).—Principal addresses, scientific papers, and panel discussions at a conference in May 1962. 282 pp., $1.50.

Measurement of Thermal Radiation Properties of Solids (NASA SP-31).—Proceedings of a symposium sponsored jointly by NASA, the Air Force, and the National Bureau of Standards. 587 pp., $3.50.

Proceedings of the NASA-University Conference on the Science and Technology of Space Exploration, Chicago, Ill., November 1962 (NASA SP-11):—

Volume 1: NASA's role in space exploration; developing special skills for research in the space sciences; impact of the space program on the universities; the role of the university in meeting national goals in space exploration; radar astronomy; the sounding rocket as a tool for college and university research; geophysics and astronomy; lunar and planetary sciences; celestial mechanics and space flight analysis; data acquisition and processing; control, guidance, and navigation; bioastronautics. 429 pp., $2.50.

Volume 2: Chemical rocket propulsion; nuclear propulsion; power for spacecraft; electric propulsion; aerodynamics; gas dynamics; plasma physics and magnetohydrodynamics; laboratory techniques; materials; structures. 532 pp., $3.

The scientific papers presented at the conference, grouped by topics, are also available as separate state-of-the-art summaries:

	Cents
Geophysics and Astronomy in Space Exploration (NASA SP-13)	35
Lunary and Planetary Sciences in Space Exploration (NASA SP-14)	55
Celestial Mechanics and Space Flight Analysis (NASA SP-15)	35
Data Acquisition from Spacecraft (NASA SP-16)	40
Control, Guidance, and Navigation of Spacecraft (NASA SP-17)	40
Chemical Rocket Propulsion (NASA SP-19)	40
Nuclear Rocket Propulsion (NASA SP-20)	45
Power for Spacecraft (NASA SP-21)	25
Electric Propulsion for Spacecraft (NASA SP-22)	35
Aerodynamics of Space Vehicles (NASA SP-23)	40
Gas Dynamics in Space Exploration (NASA SP-24)	40
Plasma Physics and Magnetohydrodynamics in Space Exploration (NASA SP-25)	50
Laboratory Techniques in Space Environment Research (NASA SP-26)	40
Materials for Space Operations (NASA SP-27)	35
Structures for Space Operations (NASA SP-28)	35

A noteworthy development of the publications program during the first half of 1964 was the issuance of a new subseries of Special Publications. These data compilations and handbooks present engineering and scientific information in conveniently useful form for those working in specific fields, saving them time-consuming searches to assemble these data. Among these publications were:

- *Thermodynamic Properties and Mollier Chart for Hydrogen from 300° K to 20,000° K* (NASA SP-3002);
- *Tables for Supersonic Flow Around Right Circular Cones at Zero Angles of Attack* (NASA SP-3004);
- *Energy Spectra and Angular Distributions of Electrons Transmitted Through Sapphire Foils* (NASA SP-3008);
- *Tables of the Composition, Opacity, and Thermodynamic Properties of Hydrogen at High Temperatures* (NASA SP-3005); and
- *Tables of Flow Properties of Thermally Perfect Carbon Dioxide and Nitrogen Mixtures* (NASA SP-3009).

These and other titles in this subgroup are available from the Office of Technical Services, U.S. Department of Commerce, Washington, D.C., 20230.

Appendix J

Major NASA Launches, January 1–June 30, 1964

Name, date launched, mission	Vehicle	Site	Results
Relay II, Jan. 21 To obtain communications satellite system and space radiation data.	Thor-Delta	AMR[1]	4,600 mile apogee 1,298 mile perigee. TV test patterns excellent.
Echo II, Jan. 25 To place inflatable plastic/aluminum balloon satellite in near-polar, near-circular earth orbit for passive radio, teletype, and facsimile communications tests; test its passive communications characteristics and performance of its rigidized shape; conduct cooperative communications test with Soviet scientists.	Thor-Agena B	PMR[2]	Objectives achieved 135-foot rigidized balloon orbited. Inflation in orbit occurred. Beacons transmitting as designed. First U.S.-U.S.S.R. joint space experiments conducted beginning Feb. 21.
Saturn I (SA-5), Jan. 29 To test Saturn I launch vehicle with live upper stage (S-IV, liquid hydrogen-fueled); to orbit spent upper stage. Fifth flight of Saturn I; first Block II Saturn; first live flight of the LOX/LH fueled second stage (S-IV).	Saturn I	AMR	Objectives achieved. Both stages performed as designed. Orbit achieved. Orbited 37,000 lbs., of which nearly 18,000 was payload.
Ranger VI, Jan. 30 To place spacecraft on lunar trajectory from earth ("parking") orbit; perform midcourse correction during lunar trajectory; obtain photos of lunar surface during last 17 minutes of flight prior to impacting moon.	Atlas-Agena B	AMR	Lunar trajectory, midcourse maneuver and lunar impact achieved. TV cameras failed to take photos of moon during final 17 minutes of flight. Impacted within 20 miles of target at speed of 5,950 m.p.h. on Feb. 2.
Ariel II (UK-C), Mar. 27 To place satellite in elliptical orbit. To investigate galactic radio noise, vertical distribution of ozone in the atmosphere, and micrometeoroid flux.	Scout	WI[3]	Objectives achieved. Equipment performed as designed.
Gemini (GT-1), Apr. 8 To place Gemini spacecraft in elliptical earth orbit. To test Titan launch vehicle system, Gemini spacecraft structural integrity, and spacecraft-launch vehicle compatibility; to demonstrate the launch vehicle and guidance systems. Spacecraft not equipped to separate from second stage.	Titan II	AMR	Orbit achieved. All test instrumentation transmitted as programed. Test objectives achieved. Decayed during 69th orbit over S. Atlantic ocean.

See footnotes at end of table.

Major NASA Launches, January 1–June 30, 1964–Continued

Name, date launched, mission	Vehicle	Site	Results
Saturn I (SA-6), May 28. To place unmanned Apollo spacecraft "boilerplate" (command and service modules) in elliptical earth orbit; test Saturn propulsion and structure, and flight control systems; prove first-second stage separation technique.	Saturn I	AMR	All systems performed as d signed; orbit achieved.

[1] AMR—Atlantic Missile Range, Cape Kennedy, Fla.
[2] PMR—Pacific Missile Range, Point Arguello, Calif.
[3] WI—Wallops Island, Va.

Appendix K

NASA Launch Vehicles

(June 30, 1964)

Vehicle	Stages	Payload in pounds			Principal use
		345-mile orbit	Escape	Mars/ Venus	
Scout	4	150–220			Launching small scientific satellites and probes (Explorer).
Delta	3	800	120		Launching scientific, meteorological, and communications satellites (TIROS, Orbiting Solar Observatory, OSO–1, Ariel, Telstar I, Relay, and Syncom II).
TAD (Thrust Augmented Delta).	3	1,000	150	120	Launching scientific, meteorological, communications, and bioscience satellites and lunar and planetary probes. (Pioneer A–D, TIROS K, TIROS operational satellite OT–3 and OT–2, Syncom C (A–27), Biosatellites C–F.)
Thor-Agena B	2	1,600			Launching scientific and applications satellites (Echo II, Nimbus, Polar Orbiting Geophysical Observatory).
TAT (Thrust Augmented Thor-Agena).	2	2,200			Launching Geophysics and Astronomy, and Applications satellites (OGO–C, D, F, and Nimbus B).
Atlas-Agena B	2½	5,000	750	400	Launching heavy scientific satellites, lunar and planetary probes (Ranger, Mariner).
Atlas-Centaur	2½	8,500	2,300	1,300	Launching heavy unmanned spacecraft for lunar soft landers (Surveyor).
Atlas D	1	(1)			Launching manned Mercury spacecraft.
Titan II	2	7,000, 87/161 elliptical orbit.			Launching manned spacecraf (Gemini).
Saturn I (formerly Saturn C–1).	2	20,000 (15,000 without restart capability).			Project Apollo.
Saturn I-B (formerly Saturn CIB).	2	28,500			Project Apollo.
Saturn V (formerly Advanced Saturn C–5).	3	220,000	90,000	70,000	Project Apollo.

[1] Only NASA application is Project Mercury—2,500 pounds in 114-mile orbit.

Appendix L NASA International Activities Summary (Cumulative to June 30, 1964)

Location [1]	Cooperative projects: Flight projects: Satellites	Cooperative projects: Flight projects: Experiments on NASA satellites	Cooperative projects: Flight projects: Sounding rockets	Cooperative projects: Ground-based projects for—: Meteorological satellites	Cooperative projects: Ground-based projects for—: Communications satellites	Cooperative projects: Ground-based projects for—: Ionosphere beacon satellites	Cooperative projects: Ground-based projects for—: Ionosphere sounding satellites	Operations support (tracking and data acquisition networks): Scientific satellite	Operations support: Manned flight	Operations support: Deep space	Operations support: Optical	Operations support: Moonwatch	Operations support: Data acquisition	Personnel exchanges: Resident associateships	Personnel exchanges: International fellowships	Personnel exchanges: Training	Personnel exchanges: Visits
Argentina			X	X		X	X				X	X			X	X	X
Australia			X	X		X		X	X	X	X	X		X		X	X
Austria				X		X						X			X		X
Belgium				X			X							X	X		X
Bermuda									X								
Bolivia							X										X
Brazil				X	X	X						X	X	X		X	X
Burma				X													X
Canada	X		X	X	X	X		X				X		X		X	X
Canton Island (U.S.-U.K.)									X								
Ceylon														X			X
Chad				X													
Chile						X	X	X				X				X	X
China, Republic of				X								X		X	X		X
Colombia				X			X							X			X
Costa Rica				X													X
Czechoslovakia				X													X
Denmark			X	X	X		X					X		X			X
Ecuador								X								X	X
El Salvador				X													X
France	X	X	X	X	X	X	X					X		X	X	X	X
Germany, Federal Republic of			X	X	X	X	X					X	X	X	X		X
Ghana						X											X
Greece						X						X		X			X
Hong Kong				X		X											
Hungary				X													X
Iceland				X													X
India			X	X		X					X	X	X	X		X	X
Indonesia				X													X
Iran											X			X			X
Iraq				X													X

Ireland				X													X
Israel						X						X		X			X
Italy	X		X		X	X						X		X		X	X
Jamaica				X		X	X										X
Japan			X	X	X	X					X	X	X	X	X	X	X
Kenya				X		X											X
Korea														X			X
Malagasy								X									X
Malaysia						X											X
Mauritius				X													
Mexico									X			X			X		X
Mozambique				X													
Netherlands				X			X				X	X		X	X		X
New Zealand			X	X		X						X		X			X
Nigeria						X			X								X
Norway			X	X	X	X										X	X
Pakistan			X									X		X	X	X	X
Peru							X	X			X	X			X	X	X
Philippines												X					X
Poland				X													X
Portugal				X								X					X
Rhodesia/Nyasaland, Federation of				X								X					X
Senegal				X													
South Africa				X				X		X	X	X				X	X
Spain					X	X	X		X	X	X				X		X
Sudan				X		X											X
Sweden			X		X	X	X							X	X	X	X
Switzerland				X		X								X			X
Tanganyika												X					X
Thailand				X		X											X
Turkey														X			X
Uganda												X					X
United Arab Republic				X													X
United Kingdom	X	X	X	X	X	X	X	X				X		X		X	X
Uruguay												X		X			X
U.S.S.R.	X																X
Zanzibar									X								X
ESRO [2]	X															X	X
Total	6	2	14	41	11	27	14	8	7	3	9	28	4	25	13	17	[3] 95

[1] Includes separate jurisdictions, Nations in process of acquiring independence, ESRO and ELDO.

[2] European Space Research Organization. ESRO-sponsored international fellows are indicated under the countries they represent.

[3] The following, included in the total, participated only in the visitor program: Afghanistan, Algeria, British Guiana, Cambodia, Cameroons, Cyprus, Dahomey, Dominican Republic, Dubai, Ethiopia, Finland, Guatemala, Haiti, Honduras, Jordan, Laos, Lebanon, Libya, Luxembourg, Morocco, Nicaragua, Panama, Paraguay, Rwanda, Saudi Arabia, Sierra Leone, Somalia, South Viet-Nam, Syria, Trinidad, Venezuela, Yugoslavia, European Launcher Development Organization (ELDO).

Appendix M

Grants and Research Contracts Obligated [1]

Jan. 1–June 30, 1964 [2]

Alabama:		
NsG–381 S 1	University of Alabama, R. Hermann and G. Croker Research in the aerospace physical sciences and engineering.	$395,995
NsG–608	University of Alabama, F. J. Tischer Investigate the wave propagation in the plasma flow field typical for capsule-type spacecraft reentering from flights.	40,000
NsG–608 S 1	University of Alabama, F. J. Tischer Wave propagation study.	40,000
NsG(T)–30 S 1	University of Alabama, E. Rodgers Support the training of 10 graduate students in space-related science and technology.	192,000
NsG(T)–18 S 1	Auburn University, W. V. Parker Support the training of 10 graduate students in space-related science and technology.	176,900
NASr–117 A 3	Southern Research Institute, A. Willhelm Effect of protective coatings on the stress-corrosion properties of supersonic transport skin materials.	36,524
Alaska:		
NsG–201 S 3	University of Alaska, S. Akasofu Theoretical study of the ring current and geomagnetic field phenomena.	40,000
NsG–459 S 1	University of Alaska, P. Morrison Experimental studies on physiological adaptation to environmental extremes.	80,000
NsG(T)–131	University of Alaska, K. M. Rae Support the training of 3 graduate students in space-related science and technology.	57,600
Arizona:		
NsG(T)–32 S 1	Arizona State University, I. Stout Support the training of 6 graduate students in space-related science and technology.	106,200
NsG–120 S 3	University of Arizona, R. W. G. Wyckoff Investigate X-rays in the region between 10 and 300A approximate with special emphasis on methods to produce and detect.	50,000
NsG–161 S 3	University of Arizona, G. P. Kuiper Conduct site testing of Mauna Kea and Mauna Loa, Hawaii.	9,375
NsG–161 S 4	University of Arizona, G. P. Kuiper Physical and structural surface studies of the moon, studies of planetary atmospheres, and related programs.	201,000
NsG–458 S 1	University of Arizona, S. A. Hoenig Development of chemisorption detectors for specific components of tenous planetary atmospheres.	60,000

See footnotes at end of table

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NsG-490 S 1	University of Arizona, L. E. WEAVER. Research in and application of modern automatic control theory to nuclear rocket dynamics and control.	$30,000
NsG-580	University of Arizona, T. L. VINCENT. A study of the calculus of variations and its applications in aerospace engineering.	16,944
NsG-628	University of Arizona, S. BASHKIN. Operation of a 2-MV Van de Graeff accelerator for basic experiments in atomic optical spectroscopy.	127,175
NsG-646	University of Arizona, G. A. KORN. Research in connection with advanced hybrid analog-digital computer systems.	21,186
NsG-681	University of Arizona, G. P. KUIPER. Solar-system studies with 16-inch telescope.	26,927
NsG(T)-33 S 1	University of Arizona, H. D. RHODES. Support the training of 10 graduate students in space-related science and technology.	177,000
NASr-218	University of Arizona, H. L. JOHNSON. Conduct a design and development study of prime experiment in stellar ex-photometry.	104,691
Arkansas:		
NsG-260 S 2	University of Arkansas, M. K. TESTERMAN. Techniques of radio frequency mass spectrometry.	39,730
NsG(T)-12 S 1	University of Arkansas, V. W. ADKISSON. Support the training of 8 graduate students in space-related science and technology.	144,000
California:		
NsG-40	California Institute of Technology, HANS LIEPMANN. Continued investigation of fluid mechanics of rarefied gases by extending shock techniques into the low pressure regime.	75,000
NsG-56 S 5	California Institute of Technology, H. BROWN. Investigation of problems of lunar and planetary exploration including meteorite composition and time of fall studies.	327,428
NsG-172 S 3	California Institute of Technology, M. WILLIAMS. Research on failure criteria for fiscoelastic materials typical of solid rocket propellants.	58,308
NsG-598	California Institute of Technology, E. E. SCHLER. Support a 6-week summer institute in space technology.	56,600
NsG(T)-37 S 1	California Institute of Technology, F. BOHNENBLUST. Support the training of 15 graduate students in space-related science and technology.	268,900
NsG-101	University of California (Berkeley), H. WEAVER, M. CALVIN, and D. REA. Research in exobiology.	94,579
NsG-104 S 2	University of California (Berkeley), W. J. OSWALD, R. C. COOPER and S. S. ELBERG. The detection and study of micro-organisms in the upper atmosphere.	31,727
NsG-126 S 1	University of California (Berkeley), S. SCHER. Biochemical activities of terrestrial micro-organisms in simulated planetary environments.	35,655
NsG-243 S 2	University of California (Berkeley), S. SILVER. The program of socioeconomic studies in the field of research and development.	500,000
NsG-255 S 2	University of California (Berkeley), H. WEAVER. A review of stratoscope II infrared observations of Mars.	17,221

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

California—Continued		
NsG–354 A 1	University of California (Berkeley), E. POLAK. Continued research in automatic control and information systems.	$18,298
NsG–387 S 1	University of California (Berkeley), K. ANDERSON. Study high energy solar flare radiation.	70,000
NsG–397 S 1	University of California (Berkeley), N. PACE. Support of White Mountain Alpine Research Station and study of the physiology of natural high-altitude hibernators.	90,000
NsG–600	University of California (Berkeley), H. JONES. Research on techniques and instrumentation for measurement of physiological variables in mammals under space flight conditions.	130,000
NsG–637	University of California (Berkeley), K. PISTER. Theory of Sandwich Plates and Shells.	17,718
NsG–702	University of California (Berkeley), A. K. OPPENHEIM. Gas-wave-dynamic studies of spray combustion.	69,675
NsG–704	University of California (Berkeley), A. D. MCLAREN. Enzyme activity in terrestrial soil in relation to exploration of the Martian surface.	58,471
NsG(T)–117	University of California (Berkeley), S. S. ELBERG. Support the training of 15 graduate students in space-related science and technology.	237,000
NASr–212	University of California (Berkeley), G. C. PIMENTAL. Develop infrared spectrometer suitable for space vehicle study of planetary atmospheres.	175,545
NASr–220	University of California (Berkeley), M. CALVIN. Develop scanning system for the Mariner spacecraft capable of measuring reflected visible radiation.	193,544
NsG–584	University of California (Davis), D. BEARD. Optical properties of plasmas and fundamental cyclotron frequencies.	4,409
NsG–705	University of California (Davis), B. COSWELL. Constitutive equations and non-Newtonian fluid mechanics.	19,200
NsG–249 S 2	University of California (Los Angeles), T. A. FARLEY. Research in particles and fields in space.	200,000
NsG–429 S 1	University of California (Los Angeles) G. MACDONALD. Support of a summer institute in planetary physics.	48,800
NsG–481 S 1	University of California (Los Angeles), I. MALKUS. Tropical cloud research in the Barbados area.	30,000
NsG–502 S 1	University of California (Los Angeles), J. D. FRENCH and W. R. ADEY. Neurophysiological and behavioral studies of chimpanzees, including establishment of group of implanted animals.	145,520
NsG–623	University of California (Los Angeles), D. B. LINDSEY. Computer analysis of brain activity in perception and performance.	65,054
NsG–672	University of California (Los Angeles), E. ROSENBERG. The Geochemistry of Nucleic Acids.	44,438
NsG–721	University of California (Los Angeles), R. E. SMITH. The role of brown fat in the thermogenesis of animals and man.	81,732
NsG(T)–4	University of California (Los Angeles), W. F. LIBBY. Support the training of 15 graduate students in space-related science and technology.	288,000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NsG(T)–130	University of California (Riverside), R. F. MARCH Support the training of 2 graduate students in space-related science and technology.	$35,400
NsG–321 S 1	University of California (San Diego), H. BROWN Study the radionuclides existing in meteorites and increase our knowledge of the interaction of cosmic rays.	51,000
NsG–357 S 2	University of California (San Diego), G. BURBIDGE and K. PRENDERGAST. Theoretical studies in astrophysics.	30,000
NsG–538	University of California (San Diego), C. E. MCILLWAIN. Study of geomagnetically trapped particles.	240,000
NsG–701	University of California (San Diego), V. R. MURTHY Nuclear history of the solar system.	44,877
NsG(T)–95	University of California (San Diego), N. W. RAKESTRAW Support the training of 6 graduate students in space-related science and technology.	96,500
NsG–722	University of California (San Fran. Med. School) V. T. INMAN Relative roles of gravitational and inertial work in the energy cost and character of human locomotion.	37,426
NsG–91 S 2	University of California (Santa Barbara), W. C. WALKER Experimental studies in ultraviolet solid state spectroscopy in the spectral.	70,076
NsG–289 S 2	Cedars of Lebanon Hospital, C. M. AGRESS A technique for testing heart function by analysis of its vibration spectrum.	200,000
NASr–21(02) A 5	Rand Corporation, G. B. EDELEN Technical studies on communication satellites.	375,000
NASr–21(05) A 2	Rand Corporation, E. H. VESTINE Theoretical studies of the earth's magnetic field and space environment near the earth.	199,800
NASr–21(07) A 2	Rand Corporation, W. W. KELLOGG Study of the methods of pattern recognition applied to cloud cover photographs from meteorological satellites.	149,799
NASr–21(08) A 2	Rand Corporation, H. L. SHULMAN A study to assist in defining a checkout system for manned mission complexes.	611,000
NASr–21(09)	Rand Corporation, H. L. SHULMAN Conduct studies with the object of providing assistance to NASA/OMSF in its contingency planning for the Apollo program.	632,906
NsG–433 S 1	University of Southern California, J. HENRY Studies of development of stress response mechanisms.	220,094
NsG–616	University of Southern California, H. S. TYLER Second order perturbation theory in atomic and molecular quantum mechanics.	16,000
NsG(T)–75 S 1	University of Southern California, M. C. KLOETZEL Support the training of 10 graduate students in space-related science and technology.	193,000
NASr–49(02) A 4	Stanford Research Institute, W. R. VINCENT Continuation and extension of measurements and analyses to ascertain the frequency of occurrence of microwave energy.	13,178

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

California—Continued		
NASr–49(02) A 5	Stanford Research Institute, W. R. VINCENT. Measurements of forward scattering in preparation at 6.0 GC.	$3,329
NASr–40(04) A 3	Stanford Research Institute, R. J. P. LYON. Further studies on emission infrared spectra from various rock materials.	5,920
NASr–49(07) A 2	Stanford Research Institute, F. SMITH. Theoretical research-electronic, ionic and atomic impact phenomena.	39,347
NASr–49(08) A 3	Stanford Research Institute, R. G. GOULD. Technical problems associated with communication satellites.	1,732
NASr–49(10) A 1	Stanford Research Institute, R. F. MARACA. Participation in the technology utilization program.	97,150
NASr–49(11) A 1	Stanford Research Institute, L. F. NEY. Studies on the hill reaction activity on soluble chloroplast extracts.	27,850
NASr–49(15) A 1	Stanford Research Institute, N. K. HIESTER. Continued research on the feasibility of simulating thermal environment for meaningful evaluation of ablating materials.	72,720
NASr–49(17) A 2	Stanford Research Institute, R. K. ARNOLD. Study of the economic impact of the establishment of an electronics research center.	18,737
NASr–49(18)	Stanford Research Institute, A. S. DENNIS. Study of the feasibility and applicability of and recommendations concerning sferics measurements.	51,222
NASr–49(19)	Stanford Research Institute, F. HALDEN. Study of growth parameters for refractory carbide single crystals.	61,460
NASr–49(21)	Stanford Research Institute, A. SHAPIRO. Studies on the structure and dynamics of the R&D industry with special reference to NASA programs.	53,163
NsG–30 S 4	Stanford University, O. K. GARRIOTT. Ionospheric research utilizing satellite transmissions.	100,000
NsG–81 S 3	Stanford University, J. LEDERBERG, C. C. LEVINTHAL and C. DJERASSI. Cytochemical studies of planetary micro-organisms.	485,120
NsG–81 S 4	Stanford University, P. Z. BULKELEY. Cytochemical studies of planetary micro-organisms.	62,984
NsG–133 S 2	Stanford University, R. CANNON. Continued research on studies on space vehicle attitude control systems.	100,000
NsG–174 S 2	Stanford University, R. A. HELLIWELL. Support of basic scientific research into the experimental techniques for the measurement of very low frequency electromagnetic phenomena in the ionosphere.	44,048
NsG–215 S 1	Stanford University, F. MORRELL and L. MORRELL. Electrophysiological correlates of vigilance.	50,000
NsG–299 S 1	Stanford University, O. BUNEMAN. Study of randomization of electron energy in plasma thermionic diodes.	38,330
NsG–377 S 1	Stanford University, V. R. ESHLEMAN. Research in space sciences at the Stanford Center for Radar Astronomy.	207,424

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NsG–378 S 1	Stanford University, W. FAIRBANK. Research on gravitational and resonance experiments on very low-energy free electrons and positrons.	$72,898
NsG–555	Stanford University, G. PEARSON. Fundamental studies on gallium phosphide.	150,000
NsG–565	Stanford University, J. B. ROSEN. Research on nonlinear programing solution of optimum control processes.	29,573
NsG–582	Stanford Univeristy, R. H. CANNON. Development of a zero-G, drag-free satellite and to perform a gyro test of general relativity in a satellite.	175,720
NsG–620	Stanford University, W. G. VINCENTI. Study and further development of the tracer-spark technique for flow velocity measurements.	36,616
NsG–622	Stanford University, A. S. TETLEMAN. Experimental study and theoretical interpretation of mechanisms of strengthening and fracture in 2 classes of composite materials.	27,150
NsG–630	Stanford University, N. J. HOFF. Buckling of complete spheres under external pressure.	46,821
NsG–703	Stanford University, P. A. STURROCK. Theoretical studies of turbulence in plasmas.	21,744
NsG(T)–76 S 1	Stanford University, F. E. TERMAN. Support the training of 15 graduate students in space-related science and technology.	310,500
NASr–228	Stanford University, M. ANLIKER. Support a 10-week summer institute in space-related engineering.	56,600
Colorado:		
NsG(T)–92	Colorado School of Mines, A. R. JORDAN. Support the training of 3 graduate students in space-related science and technology.	39,900
NASr–147 A 2	Colorado State University, W. E. MARLATT. Investigations of the temperature and spectral emissivity characteristics of cloud tops and of the earth's surface.	109,114
NsG–569	Colorado State University, K. SEO. Research on a modified Kuhn-Tucker theorem.	7,298
NsG–570	Colorado State University, L. V. BALDWIN. Transient and steady performance of ion rocket thrust augmentor.	89,586
NsG–675	Colorado State University, P. THORNTON. Immobilization and skeletal atrophy.	34,881
NsG(T)–45 S 1	Colorado State University, A. F. CLARK. Support the training of 6 graduate students in space-related science and technology.	86,500
NsG–78 S 2	Colorado State University Research Foundation, R. BAKER. Research on pathogen-free plants in a microcosmo and on the effects of high-intensity light on plant growth.	69,743
NsG–625	Colorado State University Research Foundation, J. B. BEST. Mechanisms of integration and behavior.	104,383
NsG–709	University of Colorado, D. M. GATES. Environmental biology program to study life in extreme environments.	92,504

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Colorado—Continued		
NsG(T)–46 S 1	University of Colorado, R. P. BROWDER. Support the training of 10 graduate students in space-related science and technology.	$182, 200
NASr–214	Denver Research Institute, J. S. GILMORE. Fuel cells and inorganic coatings; analysis of NASA scientific and technical contributions and their dissemination.	18, 000
NASr–214 A 1	Denver Research Institute, J. S. GILMORE. Fuel cells and inorganic coatings; analysis of NASA scientific and technical contributions and their dissemination.	9, 844
NsG–518	University of Denver, S. A. JOHNSON. Multidisciplinary research in space-related science and engineering.	200, 000
NsG–648	University of Denver, E. N. SICKAFUS. To develop a computer program for calculations on interstitial geometry in lattices of spheres.	12, 000
NsG(T)–49 S 1	University of Denver, A. C. NELSON. Support the training of 6 graduate students in space-related science and technology.	100, 800
NASr–221	The Research Institute for Biological Science, H. SWAN. Antimetabolic agent in the lung fish.	31, 000
R–30 A 2	U.S. National Bureau of Standards, R. G. MERRILL, R. S. LAWRENCE. Ionospheric studies using satellite beacon transmissions.	100, 000
R–45 A 3	U.S. National Bureau of Standards, R. SCOTT. Continued research of measurement, calculation, and correlation of hydrogen property data using cryogenic fluids.	450,000
R–45 A 4	U.S. National Bureau of Standards, R. SCOTT. Continued research of measurement, calculation, and correlation of hydrogen property data using cryogenic fluids.	75, 000
R–132	U.S. National Bureau of Standards, R. S. LAWRENCE. One-year design study and construction of a large antenna array to be used for a map of the sky at 10 megacycles.	72, 000
R–133	U.S. National Bureau of Standards, W. CALVERT and K. W. KRECHT. Develop a resonance relaxation experiment for accurate electron-density measurements.	95, 000
NsG–92 S 3	University Corporation for Atmospheric Research, H. ZIRIN and J. WARWICK. Research on new techniques of observation of solar phenomena.	80, 000
NsG–136 S 2	University Corporation for Atmospheric Research, J. WARWICK. Provide radio monitoring of solar activity and theoretical studies of flare physics.	107, 680
NsG–404 S 1	University Corporation for Atmospheric Research, G. NEWKIRK. Additional support for development of an externally occulted coronagraph for satellite use.	29, 000
NsG–404 S 2	University Corporation for Atmospheric Research, A. EDDY. Additional support for development of an externally occulted coronagraph for satellite use.	50, 000
NASr–224	University Corporation for Atmospheric Research, E. MARTELL. Investigation of trace gases and aerosols in the upper atmosphere with a cryogenic rocket sampler.	250, 000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Connecticut:		
NsG–204 S 1	University of Connecticut, W. E. HILDING. Heat transfer and flow mechanics of vapor condensing at high velocities in small straight tubes.	$67,220
NsG(T)–47 S 1	University of Connecticut, N. L. WHETTEN. Support the training of 6 graduate students in space-related science and technology.	116,800
NsG–716	Wesleyan University (Middletown), F. R. ZABRISKIE. Studies of planetary physics.	18,960
NsG–1 S 4	Yale University, V. HUGHES. Research on theoretical and experimental investigations of collision cross sections in atomic processes.	60,000
NsG–138 S 3	Yale University, R. C. BARKER. Low-power, low-speed data storage and processing techniques.	28,148
NsG–163 S 2	Yale University, V. W. HUGHES. Theoretical research in relativity, cosmology, and nuclear astrophysics.	49,946
NsG–176 S 1	Yale University, L. OSTER. Investigate by a theoretical study the radiation emitted by coronal plasma subject to collisions with streams of particles.	66,547
NsG–192 S 1	Yale University, S. R. LIPSKY. The development of certain aspects of gas chromatographic systems for planetary explorations.	68,179
NsG–208 S 1	Yale University, H. J. MOROWITZ. Studies of extremely small self-replicating systems.	42,318
NsG–724	Yale University, A. CHEN. Experimental and theoretical research on plasma sheaths and boundary layers around stagnation point electrodes.	63,321
NsG(T)–34 S 1	Yale University, D. B. H. MARTIN. Support the training of 12 graduate students in space-related science and technology.	248,400
Delaware:		
NsG–573	University of Delaware, K. BOER. To investigate the physical nature of defect in CdS produced by X-ray and electron irradiation.	24,564
NsG(T)–29	University of Delaware, J. C. KAKAVAS. Support the training of 6 graduate students in space-related science and technology.	109,600
District of Columbia:		
NASr–196 A 1	Aerospace Medical Association, W. J. KENNARD. Publishing 1964 volume of aerospace medicine abstracts, with annual index.	6,000
NASr–229	American University, M. J. PEDELTY. Review of national potential for machine intelligence research.	5,960
NsG–662	American University, C. A. GROSS. Summer seminar in space oriented mathematics designed for junior high and high school teachers.	8,778
NsG–125 S 3	Catholic University, J. H. BALTRUKONIS. Research on dynamics of solid propellant rocket motors.	27,485
NsG–586	Catholic University, C. C. CHANG. Research on hydrodynamics of gaseous-core cavity reactors.	137,120

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

District of Columbia—Continued		
NsG–647	Catholic University, R. E. MEIJER Studies of spin-phonon coupling effects using the combined techniques of electron spin resonance and acoustic excitation on the same paramagnetic crystal and same frequency.	$23,136
NsG–649	Catholic University, R. TANAKA Theoretical investigation of the analysis of radiation damage in solar cells.	24,108
NsG(T)–39 S 1	Catholic University, J. O'CONNOR Support the training of 10 graduate students in space-related science and technology.	192,800
NASr–244	Environmental Research Institute, F. D. SISLER Physical limitations of life.	12,000
NsG–428 S 1	Georgetown University, W. J. THALER Theoretical and experimental studies of radiation.	98,000
NsG(T)–98	Georgetown University, J. B. HORIGAN Support the training of 6 graduate students in space-related science and technology.	106,200
NsG–485 S 1	George Washington University, C. W. SCHILLING Scientific communication research in space biology.	80,358
NsG–603	George Washington University, N. FILIPESCU Synthesis and spectroscopic properties of rare earth chelates in solvents and polymers for optical masers.	47,040
NsG–645	George Washington University, N. T. GRISAMORE Research on 3-valued computer systems.	19,950
NsG(T)–51 S 1	George Washington, University, A. E. BURNS Support the training of 6 graduate students in space-related science and technology.	109,800
NASr–171	George Washington University, C. W. SCHILLING To provide professional supporting services for the review and evaluation of new technology identified by technology utilization.	27,000
NASr–160	Greene & Holly History of project vanguard.	29,300
NsG(T)–110	Howard University, S. L. WORMLEY Support the training of 4 graduate students in space-related sciences and technology.	81,600
NsG–34 S 4	National Academy of Sciences, C. J. LAPP Participation in the resident research associateship program.	305,373
NsG–492	National Academy of Sciences, R. J. SHAY Remote sensing as a way of determining plant populations and stresses.	7,000
NsG–697	National Academy of Sciences, H. ODISHAW Proposal for support of a working conference on space nutrition and related waste problems.	9,000
NASr–239	National Academy of Sciences, H. H. HESS Support of a study of exobiology.	172,675
R–33 A 2	National Science Foundation, H. ODISHAW Continue world data center and rockets and satellites subcenter.	22,900
R–54 A 2	National Science Foundation, G. W. MULDERS Support of Space Science Board.	107,600
R–97 A 1	National Science Foundation, R. THOMAS Support of the Committee on Space Research (COSPAR).	5,000
NASr–10 A 6	Resources Research, Inc., S. LEVIN Continuation of research on Gulliver life detector, optimizing the present system and improving reliability.	156,496

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NASr-190 A 1	Science Services, W. DAVIS. NASA award trips to NASA Research Centers.	$1,003
NsG-87 S 10	Smithsonian Institution, F. L. WHIPPLE. Support of optical satellite tracking program.	2,050,000
NsG-563	Smithsonian Institute, C. W. TILLINGHAST. Search, recovery and analysis of space fragments.	40,000
NsG-688	Smithsonian Institution, K. FREDRIKSON. Studies of constituents, compositions, and textures of meteorites, and their bearing on the theoretical problems.	200,000
NsG-35 S 4	Society of Photographic Scientists and Engineers, N. GOODWIN. Volunteer photographic tracking program during calendar year of 1964.	39,177
R-104 T 2	U.S. Atomic Energy Commission, BLIZARD, MAIENSCHEIN & ZERBY. Studies of the penetration of space vehicle structural material.	400,000
R-104 T 2 A 1	U.S. Atomic Energy Commission. Support of agreements R-41 and R-46.	200,000
R-104 T 3	U.S. Atomic Energy Commission. Studies of the penetration of space vehicle srtuctural material.	500,000
R-104 T 4	U.S. Atomic Energy Commission. Gemini human blood irradation experiment.	159,000
R-104 T 5	U.S. Atomic Energy Commission. Support of agreement R-41 and R-46.	75,000
R-104 T 6	U.S. Atomic Energy Commission, J. V. SLATER. Synergistic factors influencing embryonic differentiation and development in space environment.	19,515
R-104 T 7	U.S. Atomic Energy Commission, A. H. SPARROW. Determination of influence of space environment on mutation process using controlled gamma ray exposure as a standard.	15,000
R-104 T 8	U.S. Atomic Energy Commission. Mutagenic effectiveness of known doses of gamma irradiation combined with zero.	66,000
R-104 T 9	U.S. Atomic Energy Commission. NASA-retrospective study of radiation effects.	145,000
R-136	U.S. Department of Health, Education, and Welfare. Longitudinal study of naval flight students with particular attention to cardiovascular disease.	94,350
R-66 A 4	U.S. Department of Interior, Geological Survey. Support cosmic dust research through the last quarter of fiscal year 1964.	202,850
R-145	U.S. Department of Interior, Geological Survey, V. R. WILMARTH. Cosmic dust investigation.	24,600
R-146	U.S. Department of Interior, Geological Survey. Infrared and ultraviolet studies of terrestrial materials.	181,400
R-141	U.S. Library of Congress. Abstracting 1964 literature.	41,000
R-140	U.S. Library of Congress. Indexing abstracts for 1962–1963 literature.	10,000
R-56 A 2	U.S. National Bureau of Standards, L. A. WALL. Research on Polymer Decomposition Initiated by High Energy Radiation.	50,000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

District of Columbia—Continued

R-57 A 2	U.S. National Bureau of Standards, A. D. FRANKLIN Research on thermionic materials, including measurements of vaporization and thermionic emission of selected refractory metals and compounds.	$30,000
R-73 A 1	U.S. National Bureau of Standards, R. JOHNSTON Measuring the radiation intensities in the extreme ultraviolet region.	50,000
R-80 A 2	U.S. National Bureau of Standards, M. J. BERGER Research and studies of the penetration of high-energy radiation through matter.	63,000
R-83 A 1	U.S. National Bureau of Standards, BOWLES For the conduct of space sciences experiments at the Jicamarca Radar Observatory.	200,000
R-98	U.S. National Bureau of Standards, D. MITTLEMAN Interagency fund transfer to NBS covering work required to develop standard measurative computer tasks.	8,315
R-116	U.S. National Bureau of Standards, H. J. KOSTKOWSKI Research of method for measurement of spectral irradiance from solar simulators.	60,000
R-117	U.S. National Bureau of Standards, H. J. KOSTKOWSKI Research for the development of a stable ultraviolet source and techniques for accurate radiometry.	25,000
R-126	U.S. National Bureau of Standards, J. W. WRIGHT Ionospheric electron density studies and computations.	85,000
R-127	U.S. National Bureau of Standards, C. M. TSCHEN Research on applications of plasma dynamics and statistical mechanics to plasma propulsion.	40,000
R-130	U.S. National Bureau of Standards, LOGAN Stress corrosion of titanium alloys exposed to sodium chloride at elevated temperatures.	50,000
R-138	U.S. National Bureau of Standards, HILSENRATH, FURUKAWA, ARMSTRONG. Thermodynamic properties of molecular complexes of the C-H-O-N-S-P system.	32,000
R-113	U.S. Navy, Bureau of Ships, TAYLOR, MYERS, HARRIS, DUNTLEY. Survey of human visual capabilities in space.	13,000
R-139	U.S. Navy, Bureau of Ships, S. Q. DUNTLEY Support of the research program of the visibility laboratory into the natural phenomena of the environment.	95,000
R-9 A 3	U.S. Naval Research Laboratory, A. C. KOLB Research on ultraviolet spectroscopy using high temperature plasma sources.	75,000
R-48 A 3	U.S. Navy, Office of Naval Research, WAMSLEY Balloon flights during calendar year 1964.	262,713
R-119	U.S. Navy, Office of Naval Research, G. PATTERSON Support of the fourth international symposium on rarefied gas dynamics to be held at the University of Toronto.	3,000
R-122	U.S. Navy, Office of Naval Research, H. W. HAYES Support of the advisory center on toxicology at the National Academy of Sciences.	20,000
R-128	U.S. Navy, Office of Naval Research Long-range research program in statistical quality control and reliability.	40,000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

R–129	U.S. Navy, Office of Naval Research, L. Jeffress Research in hearing with special emphasis on the problem of info transfer in connection with frequency modulated pulses.	$49,225
R–144	U.S. Navy, Office of Naval Research Support a series of interdisciplinary conferences on a variety of biological subjects to be organized by New York Academy of Science.	90,000
R–55 A 2	U.S. Weather Bureau A program of investigations in squall lines and severe local storms in the vicinity of Norman, Okla., utilizing the F–11A.	12,562
Florida:		
NsG–278 S 2	Communications Research Institute, J. C. Lilly Continuation of NsG–278. A study of feasibility and methodology for establishing communication between man and other species.	62,000
NsG–247 S 1	Florida State University, L. Mandelkern Continued research of crystallization, crosslinking and dimensional changes in micromolecular systems.	19,200
NsG(T)–50 S 1	Florida State University, J. K. Folger Support the training of 8 graduate students in space-related science and technology.	128,700
NsG–599	University of Florida, A. Green Theoretical atmospheric physics (radiation in planetary atmospheres).	56,760
NsG(T)–13 S 1	University of Florida, L. E. Grinter Support the training of 10 graduate students in space-related science and technology.	177,000
NASr–176	University of Florida, T. D. Carr Conduct design studies and partially construct the prototype of multifrequency satellite receiver for monitoring the low frequency radiation of the planet Jupiter.	58,150
NsG–424 S 1	University of Miami, A. H. Stenning Instabilities in the flow of a boiling liquid.	44,873
NsG–621	University of Miami, H. S. Robertson Investigation of oscillations on and near the anode of a cesium vapor discharge.	20,000
NsG–689	University of Miami, S. Fox Research in the Institute of Molecular Evolution in the School of Environmental and Planetary Sciences.	100,000
NsG(T)–126	University of Miami, J. R. Owre Support the training of 4 graduate students in space-related science and technology.	70,800
NsG–610	University of South Florida, T. Helvey Support the conference on alimentation in space.	8,134
R–39 A 1	U.S.N. School of Aviation Medicine, D. E. Beischer Effect of very strong magnetic fields and magnetic field-free environments on man and animals.	102,000
R–75 S 1	U.S.N. School of Aviation Medicine, H. J. Schaefer Continued research of energy dissipation characteristics in tissue for ionizing radiation in space.	30,700
Georgia:		
NsG(T)–123	Emory University, C. T. Lester Support the training of 2 graduate students in space-related science and technology.	38,600

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Georgia—Continued		
NsG–304 S 1	Georgia Institute of Technology, H. D. Edwards. Theoretical and experimental research program involving the chemical release program.	$219,520
NsG–657	Georgia Institute of Technology, K. Crawford. The development of the School of Mechanical Engineering.	600,000
NsG(T)–1 S 2	Georgia Institute of Technology, M. J. Goglia. Support the training of 15 graduate students, in space-related science and technology.	288,000
NsG(F)–24	Georgia Institute of Technology. Construction of research laboratory facilities housing the Georgia Tech Space Sciences and Technology Center.	1,000,000
NASr–192	Georgia Institute of Technology, H. D. Edwards. Perform spectrophotometric observations of high altitude of flames.	20,539
NsG–571	Georgia Institute of Technology, J. Wang. Research for investigation of the response of shells of revolution to blast load.	17,840
NsG(T)–125	University of Georgia, G. B. Huff. Support the training of 8 graduate students in space-related science and technology.	153,600
R–137	U.S. Department of Health, Education, and Welfare. Services in support of the planetary quarantine requirements.	250,000
Hawaii:		
NsG–135 S 1	University of Hawaii, R. Steiger. Continue study of zodiacal light and airglow in Hawaii.	236,995
NsG–676	University of Hawaii, J. L. Weinberg. A comprehensive photoelectric study of the night-sky radiation over the entire visible spectrum.	72,291
NsG(T)–108	University of Hawaii, L. D. Tuthill. Support the training of 3 graduate students in space-related science and technology.	53,100
Illinois:		
NsG–127 S 2	University of Chicago, A. Turkevich. Develop procedures and techniques for facilitating analysis of data from Surveyor Alpha.	40,000
NsG–144 S 4	University of Chicago, P. Meyer. For the purpose of preparation for balloon flights and satellite experiments.	167,645
NsG–179 S 3	University of Chicago, J. A. Simpson. Research and development basic for experiments in space vehicles.	234,859
NsG–352 S 1	University of Chicago, M. Cohen. Theoretical and experimental superconductivity research.	140,000
NsG–366 S 2	University of Chicago, E. Anders. Investigate the origin, age and composition of meteorites.	81,924
NsG–441 S 1	University of Chicago, H. Fernandez-Moran. Research into molecular organization and behavior of biological systems.	200,041
NsG(T)–2 S 2	University of Chicago, W. A. Wick. Support the training of 15 graduate students in space-related science and technology.	310,500
NsG–561	Illinois Institute of Technology, A. Fejer and Michelson. Study of nonlinear stability of motion of finite rigid satellites.	19,512

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NsG–694	Illinois Institute of Technology, M. WEINSTEIN. Turbulence coefficients and stability studies for the coaxial flow of dissimilar fluids.	$66,516
NsG(T)–25 S 1	Illinois Institute of Technology, M. A. ELLIOTT. Support the training of 10 graduate students in space-related science and technology.	191,800
NASr–22 A 3	IIT Research Institute, E. HAWRYLEWICZ. Life in extraterrestrial environments.	50,000
NASr–65(01) A 3	IIT Research Institute, W. DAVIS. Radiative energy transfer on entry to Mars and Venus.	67,400
NASr–65(03) A 2	IIT Research Institute, L. CONROY. Research and construction of retrometer models for use in the international trade fair exhibit.	4,885
NASr–65(03) A 3	IIT Research Institute, H. HERASEYKO. Research for industrial evaluation and task effort to improve transfer effectiveness of NASA technology disclosures.	150,000
NASr–65(04) A 2	IIT Research Institute, R. BARNETT. Research of prestressed segmented brittle materials in aerospace structures.	54,379
NASr–65(06) A 1	IIT Research Institute, L. REIFFEL. Analysis of mission requirements for exploration of the solar system.	450,000
NASr–65(07) A 1	IIT Research Institute, G. A. ZERLAUT. Investigation of light scattering in highly reflecting pigmented coatings.	39,398
NASr–65(08)	IIT Research Institute, W. M. LANGDON. Research in backstreaming from oil diffusion pumps.	76,591
NASr–65(09)	IIT Research Institute, J. E. MORRISSEY. Graphite-metal composites.	34,710
NsG–13 S 4	University of Illinois, H. KORST. Basic research investigation on flow mechanism and heat transfer in separated flows.	90,000
NsG–376 S 1	University of Illinois, D. ALPERT. Theoretical and experimental studies of the underlying processes and techniques of low pressure measurement.	101,860
NsG–434 S 1	University of Illinois, W. J. WORLEY. Continued study of line integrals, surface integrals, volumes, centroids and moments of inertia for a class of shells of revolution and for a larger class of shells.	33,703
NsG–443 S 1	University of Illinois, H. KNOEBEL. Continued research related to experimental test of general relativity.	90,000
NsG(T)–24 S 1	University of Illinois, H. E. CARTER. Support the training of 15 graduate students in space-related science and technology.	265,500
NASr–50 A 3	Materials Research Laboratory, E. J. RIPLING. Study of elevated temperature stress corrosion of high strength sheet materials.	22,120
NsG–547	Northwestern University, A. B. CAMBEL. Study of magnetoaerodynamics drag and shock standoff distance.	120,000
NsG–597	Northwestern University. Conduct a patrol of the lunar surface with a 24-inch reflector and imagine.	123,100
NsG–605	Northwestern University, G. HERMANN. Stability of nonconservative systems.	60,385

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Illinois—Continued		
NsG–674	Northwestern University, K. G. HENIZE A wide-angle slitless spectrograph for astronomical spectroscopy in the ultraviolet.	$21,801
NsG(T)–17 S 1	Northwestern University, M. E. PRIOR Support the Training of 12 graduate students in space-related science and technology.	206,000
NsG–607	Southern Illinois University, J. LAUCHNER Study of advanced structural design concepts as might be employed in future space missions.	77,722
Indiana:		
NsG–446 S 1	Evansville State Hospital, F. C. CLARK Effects of schedule and stimulus parameters on monitoring and observing behavior.	37,358
NsG–408	University of Indiana, S. ROBINSON Anaerobic work capacity as affected by stress.	30,360
NsG–503 S 1	University of Indiana, H. R. JOHNSON Theoretical research on the steady-state interaction between radiation and matter in stellar atmospheres.	36,000
NsG(T)–15 S 1	University of Indiana, J. W. ASHTON Support the training of 10 graduate students in space-related science and technology.	192,400
NASr–232	University of Indiana, R. L. BANNERMAN Actuality documentaries for radio concerning bioastronautics, their other world.	21,525
NASr–162 A 1	University of Indiana, A. M. WIEMER Study on industrial applications of aerospace research.	300,000
NsG–339 S 1	University of Notre Dame, G. F. D'ALELIO Research on synthesis of heat-resistant polymers.	49,050
NsG(T)–65	University of Notre Dame, C. A. SOLETA Support the training of 8 graduate students in space-related science and technology.	153,600
NsG–543	Purdue University, A. K. KAMAL Study of direct and reflected Lunar radio waves.	28,800
NsG–553	Purdue University, J. C. HANCOCK The synthesis of self adaptive binary communication systems.	47,990
NsG–592	Purdue University, M. ZUCROW Research on High Pressure and Toxic Propellant Firing Facility.	410,000
NsG(T)–27 S 1	Purdue University, E. C. YOUNG Support the training of 15 graduate students in space-related science and technology.	279,000
Iowa:		
NsG–62 S 3	Iowa State University, G. K. SEROVY Research of blade element techniques to the seign and performance prediction problems for axial flow pumps.	24,920
NsG–293 S 1	Iowa State University, B. C. CARLSON Investigation of hypergeometric functions and elliptic integrals.	17,001
NsG(T)–35 S 1	Iowa State University, J. B. PAGE Support the training of 12 graduate students in space-related science and technology.	205,200
NsG–233 S 2	State University of Iowa, J. A. VAN ALLEN Research with satellites and probes.	285,060
NsG–576	State University of Iowa, K. RIM Two-dimensional elastic and viscoelastic problems with star-shaped or curvilinear polygonal boundary.	7,104

See footnotes at end of table.

Grants and Research Contracts Obligated[1]—Continued

Jan. 1–June 30, 1964[2]—Continued

NsG(T)-5 S 2	State University of Iowa, J. C. WEAVER. Support the training of 15 graduate students in space-related science and technology.	$264,200
Kansas:		
NsG-606	Kansas State University, R. PATTON. Analytical studies in the learning and memory of skilled performance.	51,879
NsG-692	Kansas State University, H. HOWE. Multidisciplinary research in the space-related sciences and engineering.	150,000
NsG(T)-54 S 1	Kansas State University, H. HOWE. Support the training of 8 graduate students in space-related science and technology.	142,200
NsG-575	University of Kansas, G. G. WISEMAN. Research to measure the temperature and electrocaloric effects in ferroelectric substances.	16,277
NsG(T)-55 S 1	University of Kansas, J. S. MCNOWN. Support the training of 8 graduate students in space-related science and technology.	143,000
Kentucky:		
NsG-393 S 1	University of Kentucky, W. S. KROGDAHL. Investigation and reformulation of the numerical for solving differential equations of state of two-electron atoms.	20,688
NsG-456 S 1	University of Kentucky, K. LANGE. Effects of gravitational forces on behavior.	181,416
NsG(T)-122	University of Kentucky, A. D. KIRWAN. Support the training of 8 graduate students in space-related science and technology.	153,600
NsG-680	Spindletop Research Center, W. E. KUHN. Feasibility of continuous forming of beren carbide monofilaments.	10,000
Louisiana:		
NsG(T)-19 S 1	Louisiana State University, M. GOODRICH. Support the training of 8 graduate students in space-related science and technology.	127,700
NsG(T)-84 S 1	Tulane University, R. M. LUMIANSKY. Support the training of 8 graduate students in space-related science and technology.	158,400
Maine:		
NsG-338 S 1	University of Maine, T. H. CURRY. Interdisciplinary studies in space science and technology.	120,000
NsG(T)-116	University of Maine, F. P. EGGERT. Support the training of 4 graduate students in space-related science and technology.	76,800
Maryland:		
NsG-450 S 1	Institute for Behavioral Research, I. GOLDIAMOND and C. B. FERSTER. Experimental studies of perceptual processes.	81,625
NsG-193 S 2	Johns Hopkins University, G. H. DIEKE. Rocket and laboratory experiments on the ultraviolet spectra of the upper Dubin atmosphere.	300,000
NsG-361 S 1	Johns Hopkins University, G. H. DIEKE. Theoretical and experimental investigation of the fundamental properties of rare earth crystals.	50,000
NsG(T)-53 S 1	Johns Hopkins University, G. WILSON. Support the training of 10 graduate students in space-related science and technology.	195,000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Maryland—Continued		
R–112	Johns Hopkins University (VIA AFOSR) B. F. CHOW Effect of reduced pressure or oxygen on gut absorption.	$20,000
NsG–5 S 2	University of Maryland, E. MASON Short range intermolecular forces and high-temperature gas transport properties.	66,000
NsG–70 S 2	University of Maryland, R. W. KRAUSS Effects of gravity free and radiation environments of space on cell division suitable for use in biosatellite.	1,775
NsG–70 S 3	University of Maryland, R. W. KRAUSS A study of physophysiology in controlled environments.	80,000
NsG–220 S 2	University of Maryland, D. A. TIDMAN Theoretical studies of low density plasmas and the application of fundamental plasma kinetic theory.	27,078
NsG–283 S 1	University of Maryland, T. D. WILKERSON Measurement of plasma properties in space and atomic collision cross sections.	40,976
NsG–359 S 1	University of Maryland, T. D. WILKERSON Laboratory investigation of the line intensities of neutral atoms of astrophysical interest.	47,000
NsG–398 S 1	University of Maryland, W. C. RHEINBOLT Multidisciplinary research on the application of high-speed computers.	335,415
NsG–436 S 1	University of Maryland, J. WEBER Experimental and theoretical research gravitational physics.	300,000
NsG–566	University of Maryland, R. C. GRENELL Neurobiological substrates of behavior.	150,000
NsG–585	University of Maryland, W. C. ERICKSON Low-frequency astronomy studies of the solar corona by provision of a suitable high-resolution antenna array.	16,500
NsG–615	University of Maryland, W. C. ERICKSON Preliminary studies in the design of a large radio telescope.	24,600
NsG–642	University of Maryland, MACDONALD Theoretical investigations of nuclear reactions and structure.	47,000
NsG–695	University of Maryland, D. TIDMAN Research in the space sciences.	131,000
NsG(T)–3 S 2	University of Maryland, R. BAMFORD Support the training of 10 graduate students in space-related science and technology.	192,000
NsG(F)–17	University of Maryland, M. MARTIN Construction of facilities to house laboratories for space-related sciences.	1,500,000
R–78 A 1	National Institutes of Health, J. FINN and F. STONE Operation and development of a center for computer technology in biomedical sciences.	100,000
NsG–670	Woodstock College, J. G. MARZOLF Theoretical and experimental studies of mutual interest to GSFC and Woodstock.	60,000
R–35 A 3	U.S. Army Biological Laboratories, C. R. PHILLIPS Studies on sterilization.	30,000
R–109	U.S. Navy Bureau of Naval Weapons, W. SHIPPEN Investigate application of long-range typhon ramjet engine.	51,000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

R–38 A 2	U.S. Naval Medical Research Center, T. H. BENZINGER. Investigation of human calorimetry and heatburst microcalorimetry.	$100,000
R–134	U.S. Naval Medical Research Center, GOLDMAN. Study mechanism of axemal conduction in non-myelinated nerve.	18,900
R–118	U.S. Naval Ordnance Laboratory, W. C. LYONS, JR. Research of boundary layer transition Reynolds number for slender cones at hypersonic speeds.	121,000
R–120	U.S. Naval Ordnance Laboratory, E. T. HOOPER, JR. Provide technical assistance to NASA experiments on magnetometer and other nonlinear magnetic devices.	100,000
R–120 A 1	U.S. Naval Ordnance Laboratory, E. T. HOOPER, JR. Instrumentation for low magnetic noise environment to evaluate highly stable low noise high sensitivity magnetometers.	60,000
Massachusetts:		
NsG–253 S 1	American Academy of Arts and Sciences, E. STEVENSON. Conduct a study of long-range national problems related to the development of the NASA program.	40,000
NASr–193 A 1	American Meteorological Society, K. C. SPENGLER. Abstracting and indexing in the 1964 volume of *Meteorological and Geoastrophysical Abstracts.*	37,500
NsG(T)–120	Boston College, J. A. DEVENNY. Support the training of 3 graduate students in space-related science and technology.	61,200
NsG(T)–107	Boston University, R. S. BEAR. Support the training of 6 graduate students in space-related science and technology.	106,200
NsG–246 S 2	Boston University Observatory, G. S. HAWKINS. Study of lunar craters and their relation to meteorites and asteroids.	12,480
NsG–375	Brandeis University, P.H. QUIMBY. Comparative study of the evolution enzymes and nucleic acids.	57,171
NsG–540 S 1	Brandeis University, J. S. GOLDSTEIN. Research in radiative transfer and related subjects.	24,514
NsG–612	Brandeis University, D. FALKOFF. Theoretical research in statistical mechanics with application to rotation phenomena.	12,420
NsG(T)–112	Brandeis University, H. WEISBERG. Support the training of 6 graduate students in space-related science and technology.	106,200
NsG(T)–93	Clark University, D. E. LEE. Support the training of 2 graduate students in space-related science and technology.	29,200
NsG–64 S 2	Harvard University, D. H. MENZEL. Study of ground-based and space vehicle infrared instrumentation for thermal photography of the moon.	234,664
NsG–89 S 1	Harvard University, D. MENZEL. Research on multicolor photoelectric photometry and polarization of the moon.	117,212
NASr–158 S 2	Harvard University, G. S. HAWKINS. Investigation of the properties, flux and trajectories of meteors.	293,637

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Massachusetts—Continued

NsG–438 S 1	Harvard University, L. GOLDBERG. Theoretical and experimental studies in ultraviolet solar physics, including construction of laboratory prototype flight experiments.	$159,000
NsG–559	Harvard University, B. BUDIANSKY. Research on fracture mechanics and thin shell analysis.	74,880
NsG–579	Harvard University, R. KING. Investigate and study experimentally the radiation and circuit properties of V-antenna for satellite application.	19,256
NsG–595	Harvard University, E. EARLEY. Interrelations between systemic and regional blood volume, blood flow and fluid and electrolyte balance.	85,397
NsG–679	Harvard University, D. M. HEGSTED. Fluoride and adaptation of calcium intake, an investigation of the roles of fluoride and adaptation in the conservation of bone mineral.	23,809
NsG–685	Harvard University, G. R. HUGUENIN. Development of theory and instrumentation for long wave-length radio astronomy observations in space for planetary, solar, and galactic research objectives.	86,000
NsG–717	Harvard University, J. MENDELSON. Conditioned avoidance behavior of paramecium aurelia.	20,205
NsG–718	Harvard University, R. MCFARLAND. Human performance in adverse environments.	56,848
NASr–158 S 2	Harvard University, C. D'ALIUOLO. Research to conduct investigation of the properties, flux, and trajectories of meteors.	100,000
NsG–719	Massachusetts General Hospital, M. S. POTSAID. Study of solid chemical radiation dosimeters.	40,210
NsG–31 S 3	Massachusetts Institute of Technology, E. MOLLO CHRISTENSEN. Experimental investigation of the effect of sound impingement upon shear flows.	13,502
NsG–117 S 4	Massachusetts Institute of Technology, N. GRANT. Alloy strengthening by fine particle dispersions.	51,600
NsG–234 S 2	Massachusetts Institute of Technology, J. F. REINTJES. Studies of the scientific aspects of Venus radar reflectivity measurements.	120,000
NsG–235 S 1	Massachusetts Institute of Technology, D. G. MARQUIS. Research on organization and management of large-scale research and development.	150,000
NsG–330 S 1	Massachusetts Institute of Technology, G. H. TOWNES. Research on optical and infrared masers.	200,000
NsG–334 S 1	Massachusetts Institute of Technology, H. ZIMMERMAN. Research on techniques of communication in the space environment.	100,000
NsG–368 S 1	Massachusetts Institute of Technology, H. A. HAUS. Research for electrohydrodynamic and magnetohydrodynamic a-c power generation.	75,000
NsG–462 S 1	Massachusetts Institute of Technology, F. O. SCHMITT. Neurosciences research program.	149,832

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NsG–577	Massachusetts Institute of Technology, L. Young and Y. Li. Research on dynamic space orientation.	$36,456
NsG(T)–20 S 1	Massachusetts Institute of Technology, H. L. Hazen Support the training of 15 graduate students in space-related science and technology.	310,500
NsG(T)–64 S 1	Northeastern University, A. A. Vernon Support the training of 4 graduate students in space-related science and technology.	68,500
NsG–291	Smithsonian Institution, F. L. Whipple Systematic inflight photography and subsequent recovery of meteroites.	280,000
NsG(T)–103	Tufts University, P. H. Flint Support the training of 3 graduate students in space-related science and technology.	58,800
R–125	USAF Cambridge Research Laboratory, R. K. Soberman. Construction and test of a dust collection payload to be flown from a Nike-Cajun rocket.	34,850
R–135	U.S. Army Natick Laboratories, L. Spane Investigations leading to personnel protective systems—passive space suits.	100,000
Michigan:		
NsG–475 S 1	Michigan State University, L. O. Augenstein The nature of micromolecular basis organization and function of nerves and brain.	95,308
NASr–219	Michigan State University, D. J. Montgomery Study of NASA-university relations.	39,986
NsG(T)–58 S 1	Michigan State University, M. E. Muelder Support the training of 10 graduate students in space-related science and technology.	192,000
NsG–86 S 4	University of Michigan, J. A. Nicholls Theoretical and experimental studies of the dynamics of reacting and charged particles in solid propellant rocket motor.	34,320
NsG–115 S 3	University of Michigan, C. Kikuchi Research of electromagnetic properties of materials for application to lasers, masers and solid-state devices.	33,504
NsG–181 S 2	University of Michigan, F. T. Haddock Investigations in radio astronomy.	2,190
NsG–344 S 1	University of Michigan, S. K. Clark Research on analysis of aircraft tires.	25,896
NsG–415 S 1	University of Michigan, H. C. Early Investigation of extremely dense plasmas at very high energy densities.	10,000
NsG–558	University of Michigan, F. T. Sun Research in application of the hodograph method of orbit and trajectory problems in space flight.	27,038
NsG–572	University of Michigan, F. T. Haddock Investigations in radio astronomy.	485,030
NsG–626	University of Michigan, J. Olds Brain changes and learning.	48,096
NsG–629	University of Michigan, C. Kikuchi Magnetic resonance investigations of radiation effects in semiconductors.	76,350
NsG–640	University of Michigan, H. C. Early Development of new methods for accelerating spherical particles to velocities in excess of 50,000 feet per second.	42,986

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Michigan—Continued		
NsG–660	University of Michigan, V. C. Liu Rarefied gas dynamics applied to upper atmosphere studies.	$60,000
NsG–677	University of Michigan, W. C. Nelson Partial support of a conference on concentrated vortex motions in fluids.	7,000
NsG–696	University of Michigan, J. E. Rowe Theoretical research in the application of nonlinear travelling wave tube theory of ionospheric phenomena.	36,000
NsG–698	University of Michigan, G. W. Stroke New principles of interferometric ruling engine control.	135,000
NsG–715	University of Michigan, M. R. Holter Multispectral sensing of agricultural crops.	135,000
NsG(T)–5 S 1	University of Michigan, D. R. A. Sawyer Support the training of 15 gradute students in space-related science and technology.	279,000
NASr–54(03) A 1	University of Michigan, L. M. Jones Studies of a more elaborate balloon system.	497,500
NASr–54(05) A 1	University of Michigan, E. J. Schaefer A program in aeronomy.	340,000
NASr–54(06)	University of Michigan, P. Howe Development of on-line man-machine system performance measurement and display technique.	90,000
NASr–54(07)	University of Michigan, J. Nicholls Study of detonation phenomena and its possible relation to rocket motor combustion instability.	100,000
NASr–54(08)	University of Michigan, L. M. Jones Measurement of atmospheric structure by satellite observations of stellar refraction.	101,750
NsG(T)–102	Wayne State University, R. M. Whaley Support the training of 5 graduate students in space-related science and technology.	80,000
NASr–175	Wayne State University, R. M. Whaley Program to accelerate the industrial application of aerospace related technology.	300,000
Minnesota:		
NsG–327 S 1	Mayo Association, E. H. Wood Cine-roentgenographic study of the heart and lungs of man during exposure to forward acceleration.	52,925
NsG–461 S 1	University of Minnesota, T. M. Tsuchiya Conference on atmospheric biology.	10,322
NsG–643	University of Minnesota, G. S. Michaelsen Bacteriology of "clean" rooms.	28,731
NsG–712	University of Minnesota, J. H. Park Nonlinear estimation in communication and control.	20,315
NsG–714	University of Minnesota, R. J. Goldstein Study of heat transfer through convective layers.	23,845
NsG(T)–7	University of Minnesota, B. Crawford Support the training of 15 graduate students in space-related science and technology.	288,000
NASr–148 A 1	University of Minnesota, R. L. Rosholt A comment edition of an administrative history of NASA through June 30, 1963.	14,653

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Mississippi:		
NsG–650	Mississippi State University, R. G. TISCHER. Determine the amounts and kinds of metabolic products exerted by hydrogenomonas eutropha during autotrophic growth.	$19,200
NSG(T)–106	Mississippi State University, J. C. McKEE. Support the training of 4 graduate students in space-related science and technology.	65,300
NsG(T)–118	University of Mississippi, L. NOBLES. Support the training of 4 graduate students in space-related science and technology.	70,800
Missouri:		
NASr–63(03) A 4	Midwest Research Institute, E. C. SNEEGAS. Stimulation of the educational, industrial and economical potential of States.	99,927
NASr–63(06) A 1	Midwest Research Institute, P. BRYANT. Extreme vacuum technology (below 10–13 Torr) including a pressure calibration study.	67,841
NASr–63(07)	Midwest Research Institute, S. L. LEVY. Investigation of the nonlinear dynamics of thin shells and plates.	44,992
NsG(T)–59 S 1	Missouri School of Mines & Metallurgy, M. BAKER. Support the training of 5 graduate students in space-related science and technology.	95,500
NsG(T)–60 S 1	University of Missouri, H. E. BENT. Support the training of 10 graduate students in space-related science and technology.	191,000
NsG–271 S 1	Saint Louis University, X. J. MUSACCHIA. Effects of radiation on gastrointestinal function and cyclic turnover of intestinal epithelium.	18,678
NsG(T)–74 S 1	Saint Louis University, R. J. HENLE. Support of the training of 10 graduate students in space-related science and technology.	175,500
NsG–185 S 3	Washington University, M. W. FRIEDLANDER. Investigation of the primary cosmic radiation at low and southern latitudes.	13,980
NsG–581	Washington University, G. E. PAKE. University-wide research program in the space-related sciences and engineering.	600,000
NsG(T)–86 S 1	Washington University, G. E. PAKE. Support the training of 10 graduate students in space-related science and technology.	193,500
NsG(F)–22	Washington University. Construction of the 4th and 5th levels of research laboratory facilities housing the physics laboratory.	600,000
Montana:		
NsG–562	Montana State College, C. P. QUESENBERRY. Research in the development of nonparametric statistical theory and methodology.	9,222
NsG(T)–113	Montana State College, L. D. S. SMITH. Support the training of 4 graduate students in space-related science and technology.	76,500
NsG(T)–114	Montana State University, F. C. ABBOTT. Support the training of 3 graduate students in space-related science and technology.	57,600
Nebraska:		
NsG(T)–94	University of Nebraska, H. E. WISE. Support the training of 6 graduate students in space-related science and technology.	104,400

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Nevada:		
NsG–464 S 1	University of Nevada, H. N. MOZINGO and D. G. COONEY. Experiments on the effects of low pressure on cellular ultrastructure and cytochemistry in plants.	$34, 996
NsG(T)–61 S 1	University of Nevada, T. D. O'BRIEN. Support the training of 4 graduate students in space-related science and technology.	50, 200
New Hampshire:		
NsG–231 S 1	Dartmouth College, C. J. LYON. Effects of plant growth hormones on plant development in the absence of gravitational effects.	49, 108
NsG–526	Dartmouth College, C. J. LYON. The growth form of leafy, branched plants and the emergence of seedings under zero gravity.	2, 580
NsG(T)–128	Dartmouth College, L. M. RIESER. Support the training of 6 graduate students in space-related science and technology.	109, 800
NsG–614	University of New Hampshire, R. E. HOUSTON. VHF absorption, cosmic ray and geomagnetic field correlation studies.	19, 979
NsG–624	University of New Hampshire, R. A. KAUFMANN and L. J. CAHILL. Program of analyzing data from past satellite magnetometer experiments.	155, 346
NsG(T)–91	University of New Hampshire, E. S. MILLS. Support the training of 4 graduate students in space-related science and technology.	77, 000
NASr–211	University of New Hampshire, E. L. CHUPP. Development of instrumentation to search for neutrons and gamma rays from solar surface nuclear reactions.	50, 000
New Jersey:		
NsG–69 S 6	Princeton University, L. CROCCO. Support of the stratoscope II balloon telescope program.	26, 000
NsG–99 S 3	Princeton University, L. CROCCO. Research to investigate the fundamental causes of combustion instability.	26, 000
NsG–306 S 3	Princeton University, R. G. JAHN. Studies of pulsed electromagnetic gas acceleration.	147, 983
NsG–414 S 1	Princeton University, L. SPITZER. Astrophysical UV studies.	87, 000
NsG–414 S 2	Princeton University, L. SPITZER. Study of an integrating television tube satellite astronomy.	23, 500
NsG–470 S 2	Princeton University, C. S. PITTENDRIGH. An experimental analysis of circadian rhythm under terrestrial conditions including techniques for studying rhythms in an orbiting satellite.	30, 000
NsG–641	Princeton University, I. GLASSMAN. Preignition and ignition processes of metals.	40, 200
NsG–664	Princeton University, D. C. LEIGH. Thermomechanical theory of non-Newtonian fluids.	28, 854
NsG–665	Princeton University, W. R. SCHOWALTER. Constitutive equations for nonviscometric flows.	30, 072
NsG(T)–38 S 1	Princeton University, D. R. HAMILTON. Support the training of 12 graduate students in space-related science and technology.	196, 600

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NASr–36 A 3	Princeton University, J. LAYTON. Research on transient pressure measuring and monitoring system for remote use on man in flight.	$60, 000
NASr–215	Princeton University, O. DILLON. Research on coupled thermomechanical effects in solids.	59, 992
NASr–216	Princeton University, J. GREY. Advanced nuclear propulsion research.	100, 000
NASr–217	Princeton University, L. CROCCO. Theoretical and experimental research on combustion instability in liquid propellant rocket motors.	250, 000
NASr–223	Princeton University, C. S. PITTENDRIGH. Circadian rhythms; an analysis under terrestrial conditions and in an orbiting biological satellite.	36, 318
NASr–231	Princeton University, J. P. LAYTON. Research on propulsion system and mission analysis pertaining to advanced launch vehicle technology.	71, 575
NsG–550	Rutgers University, B. CARROLL. Theoretical and experimental studies to determine the feasibility of highly precise means of measuring polarized lights in dense scattering media.	14, 688
NsG–550 S 1	Rutgers University, B. CARROLL. Theoretical and experimental studies to determine the feasibility of highly precise means of measuring polarized lights in dense scattering media.	15, 266
NsG(T)–97	Rutgers University, R. SCHLATTER. Support the training of 10 graduate students in space-related science and technology.	162, 600
NsG–596	Stevens Institute of Technology, W. H. BOSTICK. Research of the properties of the magnetic cavity of a dipole immersed in a plasma stream.	120, 000
NsG(T)–77 S 1	Stevens Institute of Technology, R. A. MORGAN. Support the training of 6 graduate students in space-related science and technology.	108, 000
R–114	U.S. Army Picatinny Arsenal, W. R. HILKER. Engineering, design, and fabrication of 10, delayed-action fuses.	5, 000
NsG–574	Seton Hall College, C. M. LEAVY. Effects of ionizing radiation of enzyme systems and related metabolic processes.	98, 741
New Mexico:		
NASr–115	Lovelace Foundation, W. R. LOVELACE, II. Compilation of definitive current information on space medicine.	180, 000
NsG–142 S 3	New Mexico State University, C. W. THOMBAUGH. Program of photographic, photoelectric and spectrographic observations of planets.	219, 872
NsG–372 S 1	New Mexico State University, R. LIEFELD. Research in long wavelength X-ray spectroscopy.	30,277
NsG(T)–129	New Mexico State University, E. WALDEN. Support the training of 8 graduate students in space-related science and technology.	158, 400
NsG–666	University of New Mexico, V. H. REGENER. Develop and test zodiacal light photometer as laboratory prototype.	61, 014
NsG(T)–62 S 1	University of New Mexico, W. J. PARISH. Support the training of 8 graduate students in space-related science and technology.	153, 600

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

New York:		
NsG–394 S 1	Adelphi University, D. E. CUNNINGHAM. Multidisciplinary space-related sciences and technology research.	$160,000
NsG(T)–90	Adelphi University, M. MCGRILLIES. Support the training of 3 graduate students in space-related science and technology.	57,000
NsG(T)–111	Alfred University, J. F. MCMAHON. Support the training of 2 graduate students in space-related science and technology.	26,400
NASr–130 A 4	American Institute of Aeronautics and Astronautics, J. J. GLENNON. Abstraction and indexing of the 1964 volume of the *International Aerospace Abstracts*.	1,191,984
NsG–197 S 2	City College of New York, R. I. WOLFF. Satellite motion near an oblate spheroid and interatomic potentials of binary systems.	29,204
NsG(T)–109	City University of New York, M. REES. Support the training of 4 graduate students in space-related science and technology.	76,800
NsG(T)–101	Clarkson College of Technology, H. L. SHULMAN. Support the training of 3 graduate students in space-related science and technology.	62,100
NsG–229 S 3	Columbia University, J. E. NAFE. Summer institute in space physics.	81,084
NsG–294 S 2	Columbia University, E. S. MACKLIN. Materials investigations using the field ion emission microscope.	60,000
NsG–360 S 1	Columbia University, R. NOVICK. Properties of simple atoms and ions.	58,000
NsG–442 S 1	Columbia University, H. M. FOLEY. Theoretical and experimental investigations of the microwave properties of planetary atmospheres.	30,000
NsG(T)–26 S 1	Columbia University, R. S. HALFORD. Support the training of 15 graduate students in space-related science and technology.	275,500
NASr–109 A 4	Cornell Aero Laboratory, Inc., A. HERTZBERG. Experimental and theoretical research on the flow of high temperature hydrogen through jet nozzles.	134,960
NASr–119 A 2	Cornell Aeronautical Laboratories, Inc., A. HERTZBERG. Research on the nonequilibrium flow field and the optical radiation around vehicles traveling at high altitudes and superorbital speeds.	119,846
NASr–156 A 1	Cornell Aeronautical Laboratories, Inc., J. W. FORD. Investigation of warm fog properties and fog modification concepts.	70,521
NsG–116 S 3	Cornell University, S. H. BAUER. Kinetics of chemical reactions in gases at high temperatures utilizing shock tubes and other gas dynamic techniques.	12,487
NsG–382 S 1	Cornell University, T. GOLD. Laboratory experiments relating to the lunar surface.	203,530
NsG(T)–48 S 1	Cornell University, D. BOYNTON. Support the training of 12 graduate students in space-related science and technology.	212,400
NASr–46 A 2	Cornell University, T. GOLD. Build four prototype magnetometers.	12,679
NsG–155 S 2	Dudley Observatory, C. L. HEMENWAY. Collection of micrometeorites from a Gemini space flight capsule.	299,250

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NsG(T)–121	Fordham University, J. F. MULLIGAN Support the training of 3 graduate students in space-related science and technology.	$53,100
NsG–76 S 4	New York University, R. C. SAHNI Investigations of molecular states.	41,040
NsG–90 S 3	New York University, H. MARGOLIN Investigation of the effects of pressure on metallurgical phenomena.	34,955
NsG–169 S 1	New York University, W. BRANDT Energy loss of charged particles in plasmas.	28,431
NsG–217 S 1	New York University, H. A. TAYLOR Research in the vacuum ultraviolet photolysis of nitric oxide in accordance with proposal.	25,500
NsG–499 S 1	New York University, J. E. MILLER A theoretical investigation of the properties of planetary atmospheres.	25,000
NsG–499 S 2	New York University, J. E. MILLER A theoretical investigation of the properties of planetary atmospheres.	25,000
NsG–617	New York University, B. JOSEPHSON Studies of spin lattice relaxation in insulating crystals using the new technique of absorption of microsound.	30,012
NsG–699	New York University, S. BOROWITZ Selected topics in atomic physics.	14,144
NsG(T)–40 S 1	New York University, J. R. RAGAZZINI Support the training of 15 graduate students in space-related science and technology.	258,800
NASr–183 A 1	New York University, C. MARSEL Investigations of the chemical kinetics of an advanced high energy propellant system.	50,000
NsG–589	Polytechnic Institute of Brooklyn, H. J. JURETSCHKE Research on electron and field interactions with thin films and surfaces.	75,000
NsG(T)–71 S 1	Polytechnic Institute of Brooklyn, E. WEBER Support the training of 15 graduate students in space-related science and technology.	283,500
NASr–199	Pratt Institute, D. VITROGAN Space-related teaching materials designed to serve as guides to classroom instruction.	8,000
NsG–48 S 5	Rensselaer Polytechnic Institute, E. H. HOLT Investigation of the properties of gaseous plasmas by microwave techniques.	84,019
NsG–100 S 4	Rensselaer Polytechnic Institute, S. WIBERLY Research on interdisciplinary materials.	300,000
NsG–113 S 1	Rensselaer Polytechnic Institute, J. M. GREENBERG Models of interstellar dust clouds.	69,800
NsG–158 S 1	Rensselaer Polytechnic Institute, P. HARTECK Research of fundamental atom chemistry.	30,000
NsG–290 S 1	Rensselaer Polytechnic Institute, H. B. HUNTINGTON and J. C. CORELLI Radiation damage to semiconductors and thin metallic films by high-energy electron, proton and neutron-gamma radiation.	122,688
NsG–371 S 1	Rensselaer Polytechnic Institute, F. A. WHITE and G. P. CALAME Provide a better basic understanding of radiation damage to semiconductor materials.	88,171
NsG–663	Rensselaer Polytechnic Institute, J. HUDSON Spatial nucleation and crystal growth.	109,392

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

New York—Continued		
NsG(T)-10 S 2	Rensselaer Polytechnic Institute, E. B. ALLEN. Support the training of 15 graduate students in space-related science and technology.	$302,200
NsG-209	University of Rochester, W. VISHNIAC. Microbiological and chemical studies of planetary soils.	215,950
NsG-308 S 2	University of Rochester, P. W. BAUMEISTER. The properties of multilayer optical filters.	69,276
NsG-350 S 1	University of Rochester, M. LESSEN. Investigate the feasibility of a traveling wave devise of rotationally symmetric geometry for propulsion.	60,000
NsG-469 S 1	University of Rochester, G. LOEWY. Investigation of the free vibrations of heavy concentrated masses suspended in cylindrical shell structures.	30,000
NsG-574	University of Rochester, E. KINNEN. A study of nonlinear control systems problems.	18,706
NsG-613	University of Rochester, W. D. NEFF. Investigation of the neurological correlates of information reception.	37,500
NsG(T)-73 S 1	University of Rochester, W. O. FENN. Support the training of 10 graduate students in space-related science and technology.	186,000
NASr-14 A 4	University of Rochester, R. E. HOPKINS, W. L. HYDE and M. V. R. K. MURTY. Studies of optical and mechanical design of telescopic and spectrographic equipment suitable for space environment.	74,787
NASw-107 A 4	University of Rochester, R. E. HOPKINS. Obtain additional data of experiments in the vacuum ultraviolet region.	85,000
NsG-684	Saint John's University, M. PISANO. Investigation of a sonochemical approach in sterilization problems.	17,195
NsG(T)-119	State University of New York (Stony Brook), K. D. HARTZELL. Support the training of 2 graduate students in space-related science and technology.	31,100
NsG-619	Syracuse University, K. SCHRODER. Research on creep at elevated temperatures and high vacuum.	18,180
NsG-627	Syracuse University, R. M. EVAN-IWANOWSKI. Deformations and stability of perfect and imperfect isotropic cylindrical shells.	20,400
NsG-693	Syracuse University, R. S. SLEPECKY. Studies of trace elements in the sporulation of bacteria and the germination of bacterial spores.	19,458
NsG(T)-78 S 1	Syracuse University, F. P. PISKOR. Support the training of 8 graduate students in space-related science and technology.	141,600
R-106	U.S. Atomic Energy Commission, W. BRANDT. Payment for computer usage.	133
NsG-227 S 2	Yeshiva University, L. F. LANDOVITZ. Application of statistical mechanics of nonequilibrium processes to astrophysics.	25,999
North Carolina:		
NsG-152 S 3	Duke University, T. G. WILSON. Satellite electrical power conversion systems and circuit protection.	55,000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NsG(T)–16 S 1	Duke University, R. L. PREDMORE Support the training of 10 graduate students in space-related science and technology.	$177,000
NASr–235	North Carolina Science and Technology Research Center, P. J. CHENERY Establish a regional technology transfer program emphasizing the dissemination and use of new technology.	100,000
NsG(T)–31 S 1	North Carolina State College, W. J. PETERSON Support the training of 10 graduate students in space-related science and technology.	147,000
NsG–588	North Carolina State College, R. W. LADE Theoretical and experimental studies of radiation-induced damage to semiconductor surfaces and effects of damage on device performance.	59,822
NsG–678	North Carolina State College, D. S. GROSCH The utilization of habrobracon and artemia as experimental materials in bioastronautic studies.	21,178
NsG–686	North Carolina State College, F. O. SNETANA Investigation of the permeability of parachute fabrics.	30,873
NsG(T)–63 S 1	University of North Carolina, H. HOLMAN Support the training of 10 graduate students in space-related science and technology.	186,300
NASw–59 A 7	University of North Carolina, B. D. PALMATIER Measurements of change of spectrum of primary cosmic radiation at balloon altitudes.	45,880
NsG–723	Research Triangle Institute, H. CRAMER and M. R. LEADBETTER Collection and development of material, including necessary research, for the preparation of a manuscript.	20,939
NASr–40 A 3	Research Triangle Institute, G. COX Abstracting and review service for technical literature on reliability.	63,652
NASr–222	Research Triangle Institute Study the feasibility of a piezotransistor accelerometer.	48,081
NASr–236	Research Triangle Institute, BURGER Survey of microelectronic device applications in NASA program.	21,144
North Dakota:		
NsG(T)–132	North Dakota State University, D. SCHWARTZ Support the training of 2 graduate students in space-related science and technology.	37,900
Ohio:		
NASr–100(02)	Battelle Memorial Institute, H. BATCHELDER Participation in the NASA technology utilization program.	100,000
NASr–100(03) A 1	Battelle Memorial Institute, J. F. FOSTER Development of apparatus and procedures for cultivation of hydrogen-fixing bacteria.	73,765
NASr–100(04)	Battelle Memorial Institute, F. W. FINK Research on the susceptibility of titanium alloys to hot salt stress corrosion in supersonic transport.	9,780
NASw–101 A 5	Battelle Memorial Institute, A. GILBERT Investigation of mechanical properties of chromium and chromium-rhemium-type derived alloys.	40,400
NsG–36–60 S 2	Case Institute of Technology, W. MERGLER Investigation of hybird numerical circuitry in closed loop control system.	60,000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Ohio—Continued		
NsG–36–60 S 3	Case Institute of Technology, W. MERGLER. Investigation of hybird numerical circuitry in closed loop control system.	$60,000
NsG–110 S 4	Case Institute of Technology, L. A. SCHMIT, Jr. Research on a method of systematic structural synthesis suitable for use with digital computing equipment.	38,100
NsG–198 S 3	Case Institute of Technology, O. K. MAWARDI. Research in plasma dynamics.	150,000
NsG–345 S 1	Case Institute of Technology, W. TOBOCMAN. Investigate the range of validity of the theory of the direct interaction of the nuclei.	24,986
NsG–391 S 1	Case Institute of Technology, S. OSTRACH. General study of the dynamics and stability of ablative melt layers.	31,200
NsG–639	Case Institute of Technology, J. F. WALLACE. Modified eutectic alloys for high temperature service.	12,720
NsG–644	Case Institute of Technology, W. THOMPSON. Spectroscopy of trapped free radicals from low temperature hydrogen atom reactions.	48,200
NsG(T)–42 S 1	Case Institute of Technology, L. GORDON. Support the training of 10 graduate students in space-related science and technology.	206,700
NsG–654	Case Institute of Technology, S. V. RADCLIFFE. Effects of hydrostatic pressure cycling on the mechanical behavior of body centered cubic refr. metals and alloys.	19,930
NASr–227	Case Institute of Technology, R. E. BOLZ. Support a specialized summer institute in space-related engineering.	54,787
NsG–75 S 1	University of Cincinnati, B. BLACK-SCHAFFER. Protection against acceleration by immersion during hypothermic suspended animation.	21,460
NsG(T)–43 S 1	University of Cincinnati, C. CROCKETT. Support the training of 8 graduate students in space-related science and technology.	117,600
NsG–568	Kent State University, T. BHARGAVA. Research on stochastic models for multidimensional, multivalued relations.	11,400
NsG(T)–56 S 1	Kent State University, C. G. WILBER. Support the training of 3 graduate students in space-related science and technology.	54,100
NsG–213 S 2	Ohio State University, C. LEWIS. Theoretical and experimental analysis of the electromagnetic scattering on lunarlike surfaces.	100,000
NsG–295 S 1	Ohio State University, E. P. HIATT. Biological effects of prolonged exposure of animals to unusual gaseous environments.	90,000
NsG–74 S 3	Ohio State University, C. A. LEVIS. Research on receiver techniques for use at millimeter and submillimeter wavelengths.	100,000
NsG–552	Ohio State University, C. V. HEER. Research measurement of angular rotation with photons.	70,420
NsG–591	Ohio State University, R. BRODKEY. Rheological properties of materials.	20,016
NsG–652	Ohio State University, G. W. WHARTON. Determination of minimum concentrations of environmental water capable of supporting life.	69,805

See footnotes at end of table.

Grants and Research Contracts Obligated[1]—Continued

Jan. 1–June 30, 1964[2]—Continued

NsG(T)–66 S 1	Ohio State University A. C. BROAD Support the training of 8 graduate students in space-related science and technology.	$120,000
NsG(T)–133	Ohio State University, W. F. ASHE Support the specialized post-M.D. training in aerospace medicine.	71,400
NsG(T)–124	Ohio University, D. R. CLIPPINGER Support the training of 2 graduate students in space-related science and technology.	34,100
NsG(T)–104	University of Toledo, A. N. SOLBERG Support the training of 4 graduate students in space-related science and technology.	60,000
R–115	U.S. Air Force (Wright-Patterson), M. SYNDER Development of a data bank technology.	50,000
NsG–653	Western Reserve University, B. CHANDRASEKHAR Studies on the electronic structure and transport phenomena in alloys.	30,000
NsG–655	Western Reserve University, K. J. CASPER Semiconductor radiation detectors.	39,789
NsG(T)–88 S 1	Western Reserve University, F. H. HURLEY Support the training of 8 graduate students in space-related science and technology.	141,660
Oklahoma:		
NsG–300 S 1	Oklahoma City University, J. P. JORDON Interdisciplinary studies of the effects of the space environment of biological systems.	100,000
NsG–454 S 1	Oklahoma State University, J. WIEBELT Analytical and experimental studies of the thermal characteristics of a slotted, variable surface configuration for self-regulating, spacecraft temperature control system.	19,327
NsG–609	Oklahoma State University, C. A. DUNN Research in space-related sciences and engineering.	150,000
NsG(T)–67 S 1	Oklahoma State University, M. T. EDMISON Support the training of 10 graduate students in space-related science and technology.	162,000
NASr–7	Oklahoma State University, F. C. TODD Physics of hypervelocity microparticle impact.	48,000
NsG(T)–36 S 1	University of Oklahoma, A. H. DOERR Support the training of 10 graduate students in space-related science and technology.	177,000
NASr–178	Southeastern State College, W. N. PEACH Establishing and operating a technology use services center.	125,000
Oregon:		
NsG(T)–68 S 1	Oregon State University, H. P. HANSEN Support the training of 8 graduate students in space-related science and technology.	149,500
Pennsylvania:		
NsG(T)–41 S 1	Carnegie Institute of Technology, C. L. McCABE Support the training of 12 graduate students in space-related science and technology.	225,100
NsG–270 S 2	Drexel Institute of Technology, P. C. CHOU Theoretical analysis of the stresses induced into the walls of a liquid filled propellant tank impacted and penetrated by a small hypervelocity particle.	16,829
NASr–145 A 2	Franklin Institute, A. LAWLEY and J. BREEDIS Research on the effect of nucleation of slip at the surface on the flow and fracture of beryllium.	72,747

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Pennsylvania—Continued		
NASr–146 A 1	Franklin Institute R. M. Goodman. Research into measurement, systems, and systems concepts for application to studies in circadian rhythms.	$97,331
NsG–287 S 1	Haverford College, L. C. Green. Theoretical studies of wave functions and transition probabilities for light atoms and highly ionized ions.	36,201
NsG–287 S 2	Haverford College, L. C. Green. Investigation of the solar ultraviolet spectrum of FE II.	36,285
NsG–410 S 1	LeHigh University, P. C. Paris. Theoretical and experimental studies of fatigue crack propagation.	48,000
NsG–466 S 1	LeHigh University, F. P. Beer. Analysis and prediction of launch vehicle response to a random wind-velocity field.	18,960
NSG(T)–57 S 1	LeHigh University, R. D. Stout. Support the training of 8 graduate students in space-related science and technology.	153,600
NsG–147 S 2	Mellon Institute, D. J. Plazek. Research on viscoelastic behavior of polymers at long times.	24,649
NsG–668	Mellon Institute, L. Vassamillet. Research on tektites, strong meteorites, and radiation damage in simulated lunar materials.	45,000
NsG–134 S 3	Pennsylvania State University, J. S. Nisbet. Theoretical and analytical research on electron densities in the ionosphere, including studies of a rocket and separating capsule experimental technique.	116,468
NsG–324 S 1	Pennsylvania State University, E. C. Pollard. Physics of cellular synthesis, growth and division.	193,625
NsG–537	Pennsylvania State University, G. Wislicenus. Investigation of secondary flow in axial flow inducers.	29,250
NsG–611	Pennsylvania State University, D. Kline. Thermal conductivity studies of high polymers.	28,920
NsG(T)–22 S 1	Pennsylvania State University, H. K. Schilling. Support the training of 12 graduate students in space-related science and technology.	212,400
NsG–316 S 2	University of Pennsylvania, M. Altman. Research in the conversion of various forms of energy by unconventional techniques.	213,700
NsG–667	University of Pennsylvania, W. C. Forsman. Studies of non-Newtonian fluid.	28,067
NsG(T)–69 S 1	University of Pennsylvania, A. N. Hixson. Support the training of 12 graduate students in space-related science and technology.	230,400
NASr–191	University of Pennsylvania, P. S. Balas. Operation of a power information center.	182,292
NASr–191 A 1	University of Pennsylvania, P. S. Balas. Operation of the power information center.	70,000
NsG–593	University of Pittsburgh, A. J. Cohen. Geochemical research on stony meteorites and tektites.	60,000
NsG–631	University of Pittsburgh, W. M. Laird. Investigation into the mechanical properties of plastic materials.	19,200

See footnotes at end of table.

Grants and Research Contracts Obligated[1]—Continued

Jan. 1–June 30, 1964[2]—Continued

NsG–634	University of Pittsburgh, W. M. LAIRD Dynamic and static analysis of structures with uniformly distributed axial load.	$21,450
NsG(T)–70 S 1	University of Pittsburgh, P. F. JONES Support the training of 12 graduate students in space-related science and technology.	217,600
NASr–169 A 1	University of Pittsburgh, N. WALD Research on the utilization of automatic electronic scanning and computer analysis of chromosomes.	30,000
NASr–234	University of Pittsburgh, E. MONTGOMERY Development of a prototype of a regional facility for the spinoff of space information to foster industrial development.	150,000
NsG–84 S 5	Temple University, J. L. BOHN Development of experimental and statistical methods for obtaining and interpreting micrometeorite data from space vehicles.	23,000
NsG–84 S 6	Temple University, J. L. BOHN Development of experimental and statistical methods for obtaining and interpreting micrometeorite data from space vehicles.	165,000
R–121	U.S. Naval Air Engineering, J. PICHTELBERGER Research on plentum chamber combustion.	147,899
Rhode Island:		
NsG–373 S 1	Brown University, H. FARNSWORTH Structure of atomically clean surfaces of refractory metals.	67,200
NsG(T)–127	Brown University, R. B. LINDSAY Support the training of 10 graduate students in space-related science and technology.	180,000
NsG(T)–72 S 1	University of Rhode Island, E. W. HARTUNG Support the training of 4 graduate students in space-related science and technology.	70,800
South Carolina:		
NsG–(T)–44	Clemson College, H. MACAULAY Support the training of 5 graduate students in space-related science and technology.	95,300
NsG–(T)–115	University of South Carolina, R. H. WIENEFELD Support the training of 5 graduate students in space-related science and technology.	97,100
R–124	U.S. Atomic Energy Commission, S. P. RIDEOUT Stress corrosion cracking of titanium alloys.	70,000
Tennessee:		
NsG–351 S 1	University of Tennessee, J. HUNG Optimization of data by parallel data reduction.	24,000
NsG–539	University of Tennessee, N. M. FAILAR Investigation in the region of various atmospheric gases.	157,426
NsG–587	University of Tennessee, W. STAIR Fundamental study of clearance type dynamic shaft seals.	27,096
NsG–671	University of Tennessee, D. C. BOGUS Constitutive equations in two-dimensional flow.	14,537
NsG–(T)–81 S 1	University of Tennessee, H. A. SMITH Support the training of 10 graduate students in space-related science and technology.	177,000
NsG–465 S 1	Vanderbilt University, C. W. WILSON, Jr. and R. G. STEARNS Study of Wells Creek Basin, Tenn., a meteorite impact structure.	32,200

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Tennessee—Continued		
NsG–(T)–85 S 1	Vanderbilt University, L. B. BEACH. Support the training of 10 graduate students in space-related science and technology.	$179, 300
Texas:		
NsG–548	Arlington State College, G. McCAIN. Study of the effects of protective filters and lenses on color judgment.	13, 287
NsG–390 S 1	Baylor University, P. KELIAWAY. Study of correlations between physiological and psychological observations.	34, 473
NsG–269 S 2	Graduate Research Center, F. S. JOHNSON. Fundamental research in earth and planetary sciences.	850, 000
NsG–583	Graduate Research Center of the Southwest, R. C. PEANEY. Support of a symposium on gravitational collapse and other topics in relativistic astrophysics as described.	8, 000
NASr–177	Graduate Research Center of the Southwest, W. B. HANSON. Measurement of the neutral composition of the upper atmosphere.	131, 792
NsG(T)–52 S 1	University of Houston, J. C. ALLRED. Support the training of 10 graduate students in space-related science and technology.	177, 000
NsG–6 S 5	Rice University, F. BROTZEN. Research on the physics of solid materials, and study of the basic laws governing the behavior at high temperatures.	300, 000
NsG–673	Rice University, F. C. MICHEL and A. J. DESSLER. Develop an instrument to determine the species of the solar wind for advanced pioneer mission.	62, 651
NsG(T)–9 S 2	Rice University, F. R. BROTZEN. Support the training of 15 graduate students in space-related science and technology.	288, 000
NsG(F)–20	Rice University. Construct a space science and technology building on campus.	1, 600, 000
NASr–209 A 1	Rice University, B. J. O'BRIEN. Investigations and analyses of particle and light flux in aurorae and airglow using rocket-borne instrumentation.	60, 000
NsG–708	Southern Methodist University, G. W. CRAWFORD. Research in semiconductor detector-dosimeter characteristics as applied to the problems of whole body dosimeters.	76, 769
NsG–711	Southern Methodist University, H. A. BLUM. Heat transfer across surfaces in contract: practical effects of transient temperature and pressure environment.	28, 174
NsG(T)–99	Southern Methodist University, C. C. ALBRITTON. Support the training of 3 graduate students in space-related science and technology.	54, 000
NASr–94(02) A 2	Southwest Research Institute, H. KORP. Participation in the NASA Technology Utilization Program.	100, 000
NASr–94(03) A 1	Southwest Research Institute, H. N. ABRAMSON. Experimental and analytical studies on the nonlinear response of the elastic shell.	8, 000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NASr–94(06)	Southwest Research Institute, H. N. ABRAMSON Research on dynamics of shells of arbitrary geometry.	$45,101
NASr–94(07)	Southwest Research Institute, H. N. ABRAMSON Preparation of a monograph on liquid dynamic behavior in rocket propellant tanks.	74,200
NsG–239 S 2	Texas A. & M. College, F. J. BENSON Interdisciplinary Space-Oriented Research Program in the physical, life, and engineering sciences.	56,000
NsG–256 S 2	Texas A. & M., R. WAINERDI Research on remote automatic neutron activation techniques to determine lunar surface elemental composition.	67,820
NsG–669	Texas A. & M. University, A. E. CRONK Improvement of propeller static thrust estimation.	85,002
NsG(T)–8 S 2	Texas A. & M. University, W. C. HALL Support the training of 12 graduate students in space-related science and technology.	230,400
NsG(F)–16	Texas A. & M. University Construction of research laboratory facilities housing the Texas A. & M. University's activation analysis research laboratory.	1,000,000
NsG(T)–105	Texas Christian University, J. M. MOUDY Support the training of 3 graduate students in space-related science and technology.	51,900
NsG–720	Texas Technological College, F. A. WADE Collection of meteoric dust particles during Gemini flight; analyses and comparison with meteoric dust at and below surface of the earth.	24,474
NsG(T)–82 S 1	Texas Technological College, F. D. RIGBY Support the training of 6 graduate students in space-related science and technology.	101,600
NsG–210 S 2	University of Texas, P. MONTGOMERY Influence of gravity on unicellular organisms.	80,000
NsG–353 S 1	University of Texas, J. HANCOCK Research of hydromagnetic and ion cyclotron waves in plasmas immersed in magnetic fields.	39,935
NsG–432 S 1	University of Texas, C. W. TOLBERT Research on millimeter wavelength radiation utilizing 16-foot parabolic reflecting antenna.	60,000
NsG–604	University of Texas, L. REESE Procedures for modeling soils for impact studies of model spacecraft.	50,000
NsG(T)–83 S 1	University of Teaxs, W. G. WHALEY Support the training of 12 graduate students in space-related science and technology.	158,400
NASr–87 A 1	University of Texas, A. W. STRAITON Study of planetary temperatures of the brightness of radio sources.	74,000
NsG–440 S 1	Texas Woman's University, B. MACK Fundamental investigation of losses of skeletal mineral in young adult males.	90,000
R–99 A 1	USAF Aerospace Medical Laboratory, J. E. MOYER Ecologic relationships between bacteria and algae in photosynthetic gas exchangers.	20,439
R–123	USAF Aerospace Medical Laboratory, D. FARRER Research and development of a flight experiment on mice in long-duration Aero–G.	30,000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

Utah:		
NsG(T)-96	Brigham Young University, W. P. LLOYD Support the training of 4 graduate students in space-related science and technology.	$40,800
NsG(T)-80 S 1	Utah State University, J. S. WILLIAMS Support the training of 4 graduate students in space-related science and technology.	73,200
NsG(T)-79 S 1	University of Utah, H. EYRING Support the training of 8 graduate students in space-related science and technology.	141,600
Vermont:		
NsG-241 S 1	University of Vermont, A. CROWDELL Radioactive tracer and work function study of chemisorption of glass on metals.	7,000
NsG(T)-28 S 1	University of Vermont, W. H. MACMILLIAM Support the training of 4 graduate students in space-related science and technology.	67,800
Virginia:		
NsG-156 S 1	Medical College of Virginia, J. L. PATTERSON, JR. Analysis of mechanisms of control of cerebral circulation.	63,000
NsG-602	Old Dominion College, W. MAURICE PRITCHARD Defect annealing in irradiated semiconductors.	24,000
NASr-226	Virginia Associated Research Center, D. Y. PASCHALL Support a specialized summer institute in space-related engineering.	69,475
NsG(T)-11 S 1	Virginia Polytechnic Institute, W. B. BELL Support the training of 10 graduate students in space-related science and technology.	177,000
NsG-578	University of Virginia, K. ZIOCK Study the desirability and feasibility of large aperture orbiting X-ray telescope with respect to the MORL.	3,720
NsG-635	University of Virginia, J. W. MOORE Research on methods of electronic digital computer for comparison with older methods.	8,741
NsG-682	University of Virginia, F. HEREFORD Multidisciplinary research in space sciences and technology.	400,000
NsG(T)-14 S 1	University of Virginia, F. L. HEREFORD Support the training of 10 graduate students in space-related science and technology.	163,700
NASr-233	University of Virginia Contract for the use of the 26-inch telescope at the Leander McCormick Observatory, University of Virginia.	2,700
NsG-636	College of William and Mary, W. O. FUNSTEN Study of pion and muon beam transport systems for a 600 Mev synchrocyclotron.	38,700
NsG-710	College of William and Mary, T. D. LAWRENCE Measurement of light scattered by the atmosphere from a laser beam.	41,270
Washington:		
NsG(T)-100	Washington State University, D. S. FARMER Support the training of 6 graduate students in space-related science and technology.	100,700
NsG-519	University of Washington, F. B. TAUB Effects of weightlessness on the life cycle of daphania.	26,932
NsG-632	University of Washington, J. K. BUETTNER Evaluation of new methods to be used in weather satellites.	75,000

See footnotes at end of table.

Grants and Research Contracts Obligated [1]—Continued

Jan. 1–June 30, 1964 [2]—Continued

NsG(T)-87 S 1	University of Washington, J. L. McCarthy. Support the training of 10 graduate students in space-related science and technology.	$148,800
West Virginia:		
NsG(T)-21	West Virginia University, J. F. Golay. Support the training of 8 graduate students in space-related science and technology.	151,800
Wisconsin:		
NASr-143 A 1	Astronautics Corp. of America, R. D. Seinfeld. Engineering and technician field support for installation of ACA stable platform in the X-15 research vehicle.	115,063
NsG-601	University of Wisconsin, P. Myers. Research on oscillatory combustion and fuel vaporization.	140,000
NsG-618	University of Wisconsin, A. D. Code. Stellar spectrophyotemetry in the far ultraviolet.	230,420
NsG(T)-23 S 1	University of Wisconsin, R. A. Alberty. Support the training of 12 graduate students in space-related science and technology.	223,200
Wyoming:		
NsG-658	University of Wyoming, J. C. Bellamy. Orbital operational studies.	83,000
Foreign:		
NsG-54 S 3	University of Auckland, J. E. Titheridge. Investigation of radio signals from artificial satellites.	22,000
NsG-320 S 1	Dominion Observatory (Canada), V. Gaizauskas. Monitor the sun for solar activity on a daily basis and report activity noted to the NDS.	40,000
NASr-210	Institute for Fotogrammetri (Sweden), D. Hallert. Mathematical analysis of the lunar maps made by the Army Map Service and the Air Force Aeronautical Chart and Information Center.	1,980
NsG-297 S 1	University of Manchester (England), Z. Kopal. Operate a lunar and planetary observing station.	17,744
NsG-305 S 1	University of Munich (Germany), F. Moller. Evaluation of TIROS III radiation data.	15,000
NsG-633	University of Toronto (Canada), I. Glass. Research on hypervelocity reentry problems.	59,400
NsG-661	University of Toronto, R. Ribner. Research on jet noise and turbulence.	11,800
NASr-174	University of Uppsala (Sweden), K. Bockasten. Study of highly ionized light elements as found in the sun and other astronomical sources.	15,000

[1] The grants listed in this appendix are reported to the Congress in compliance with the requirements of the Grants Statute, 42 U.S.C. 1891–1893 (72 Stat. 1793).

[2] Contracts have prefix NAS; Grants have prefix NsG; Transfer of Funds to Government Agencies have prefix R. Earlier Grants and Contracts are listed in appendices of previous NASA Semiannual Reports to Congress.

Appendix N

Institutions Currently Participating in the NASA Predoctoral Training Program

(June 30, 1964)

*Adelphi University
Alabama, University of
*Alaska, University of
*Alfred University
Arizona State University
Arizona, University of
Arkansas, University of
Auburn University
*Boston College
*Boston University
*Brandeis University
*Brigham Young University
Brooklyn, Polytechnic Institute of
*Brown University
California Institute of Technology
*California, University of, Berkeley
California, University of, Los Angeles
*California, University of, Riverside
*California, University of, San Diego
Carnegie Institute of Technology
Case Institute of Technology
Catholic University of America
Chicago, University of
Cincinnati, University of
*Clark University
*Clarkson College of Technology
Clemson University
*Colorado School of Mines
Colorado State University
Colorado, University of
Columbia University
Connecticut, University of
Cornell University
*Dartmouth College
Delaware, University of
Denver, University of
Duke University
*Emory University
Florida State University
Florida, University of
*Fordham University
George Washington University
*Georgetown University
Georgia Institute of Technology
*Georgia, University of
*Hawaii, University of
Houston, University of
*Howard University
Illinois Institute of Technology
Illinois, University of
Indiana University
Iowa, State University of
Iowa State University
Johns Hopkins University
Kansas State University
Kansas, University of
Kent State University
*Kentucky, University of
Lehigh University
Louisiana State University
*Maine, University of
Maryland, University of
Massachusetts Institute of Technology
*Miami, University of
Michigan State University
Michigan, University of
Minnesota, University of
*Mississippi State University
*Mississippi, University of
Missouri, University of
Missouri School of Mines and Metallurgy
*Montana State College
*Montana State University
*Nebraska, University of
Nevada, University of
*New Hampshire, University of
*New Mexico State University
New Mexico, University of
*New York, The City University of
*New York, State University of, Stony Brook
New York University
North Carolina State College
North Carolina, University of
*North Dakota State University
Northeastern University
Northwestern University
Notre Dame, University of
Ohio State University
*Ohio University
Oklahoma State University
Oklahoma, University of
Oregon State University
Pennsylvania State University
Pennsylvania, University of
Pittsburgh, University of
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Rhode Island, University of
Rice University
Rochester, University of
*Rutgers, The State University
Saint Louis University
*South Carolina, University of
Southern California, University of
*Southern Methodist University
Stanford University

Institutions Currently Participating in the NASA Predoctoral Training Program—Continued

Stevens Institute of Technology
Syracuse University
Tennessee, University of
Texas A. & M. University
*Texas Christian University
Texas Technological College
Texas, University of
*Toledo, University of
*Tufts University
Tulane University
Utah State University
Utah, University of
Vanderbilt University
Vermont, University of
Virginia Polytechnic Institute
Virginia, University of
*Washington State University
Washington University (St. Louis)
Washington, University of (Seattle)
*Wayne State University
West Virginia University
Western Reserve University
Wisconsin, University of
Yale University

*Institutions entering the program in Fiscal Year 1964.

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